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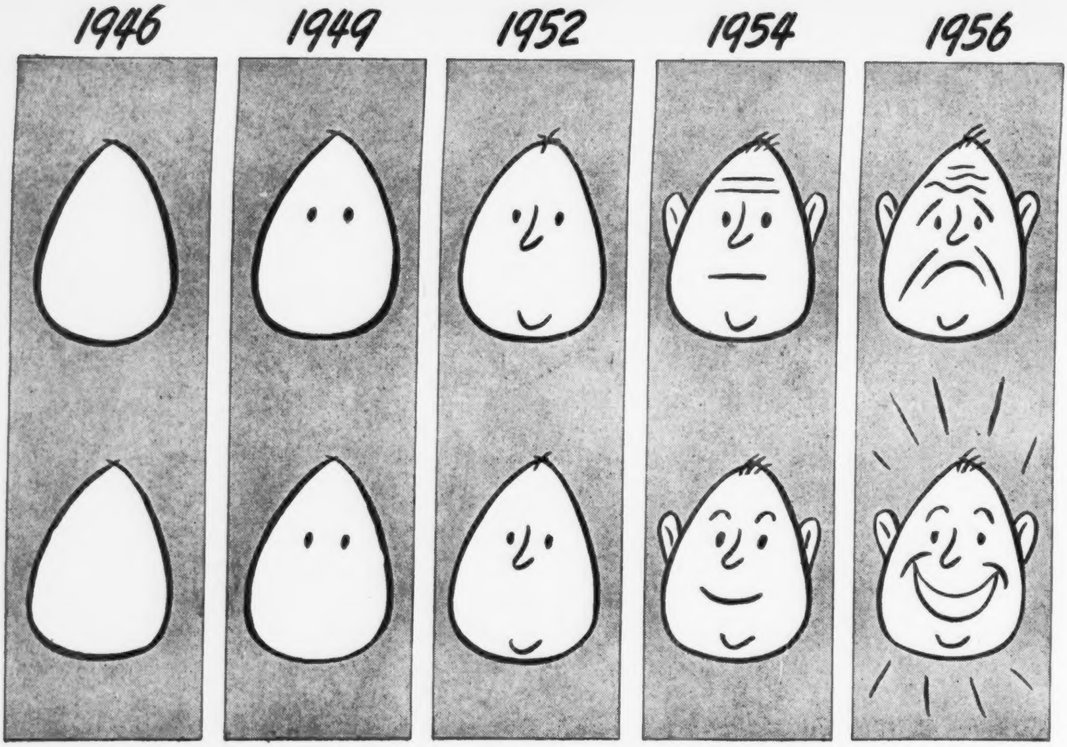
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STRATEGIC MINERAL SUPPLIES*

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SOON after the War Production Board was set up, early in 1942, it issued a pamphlet called "Federal Aids for War Mineral Production," with the subtitle "How to Get Help from the Federal Government for Development and Increasing Output of Mineral Properties." It pointed out that ores and minerals were urgently needed for America's war effort. Ores of 25 different metals, from aluminum to zinc, and 23 miscellaneous minerals, from arsenic to zircon, were enumerated. In carrying out its responsibilities to obtain these required ores and minerals the War Production Board coordinated into the war mineral program the United States Geological Survey, the Bureau of Mines, the Reconstruction Finance Corporation, and the Board of Economic Warfare. I propose to outline only the impact of the war on the activities of geologists, official and unofficial, in connection with the procurement plans for obtaining from domestic sources the necessary mineral supplies.

There were four jobs that these geologists had to do:

The first task was to determine the availability of raw materials, without which no weapons of war can be made. Authoritative information on how much ore is available is fundamental for any procurement plan, as well as for any intelligent national mineral policy. To obtain this information most of the actual and potential producing properties, scattered throughout the 48 states and Alaska, had to be inventoried by geologists. Their estimates of ore available were expressed in three categories: (1) measured ore, which is computed from known dimensions and whose grade is known from detailed sampling; (2) indicated ore, which is computed partly from measurements and partly from dimensions based on geologic evidence; and (3) inferred ore, estimated chiefly on geologic evidence and based on few if any samples. Only by detailed geologic examination in the field can this information be got; and at the same time the vital matter of the rate at which the ore can be produced at given prices of the metal can be obtained.

A second duty that geologists have been performing is geologic supervision at operating properties. Large corporations have resident geologic staffs—Anaconda Copper Co. at Butte, Montana, for example, has a staff of 35 geologists, but the smaller companies cannot afford them. As an unprecedented war measure, the U. S. Geological Survey supplied many of these mines with resident consulting geologists, either from its own staff or from the universities of the country. These geologists were then left

* From an address before the Yale Chapter of Sigma Xi, April 1945.

at the mines to cope with the geologic problems as they arose. Their principal problems were to discover more ore and to find the missing segments of ore bodies that had been dislocated by faults and become lost, as it were.

The third job undertaken by geologists was to find more ore in the known producing districts. By an intensive study of a producing district, in which innumerable openings disclose the ore bodies in three dimensions, the special features can be ascertained that determine where the ore is and why it is where it is. When these idiosyncrasies of ore occurrence peculiar to the individual districts are grasped, they can be used as guides in the search for more ore. This method has to date been by far the most successful procedure in finding new supplies of ore.

The fourth duty laid upon the geologist is the most difficult of all; it is the one generally expected of him by the layman; namely, the finding of new districts. We now have a vast body of information concerning the occurrence of the 92 chemical elements in the earth's crust and how they have at some places become concentrated into bodies of economic value. But it is not yet known *why* any mining district is located where it is. Let me illustrate. The world's supplies of the chief industrial metals—copper, zinc, lead, tin, tungsten, and molybdenum — are to be regarded as minor by-products of mighty geologic processes. The sequence of events that leads to the forming of an ore body of these metals can be summarized thus: First there was a downwarping of the earth's crust, forming a narrow trough hundreds of miles long—a geosyncline, Dana called it. It slowly deepens, and as it does so marine sediments accumulate in it, keeping it filled up nearly to sea level. In the fullness of time—I mean fullness in the geologic sense, many million years—when strata on the order of 40,000 feet in thickness have accumulated in the geosyncline, a mountain-making revolution sets in. The great pile of strata in the geosyncline is subjected to immense lateral pressure; the strata are folded and the folds are crowded together, and a mountain range is born. Under the additional load thus put on the crust by the closely appressed strata, the bottom of the folded tract sinks deeper into the subcrust. Simultaneously, enormous volumes of molten rock-matter, hundreds or thousands of cubic miles in extent, rise from the depths and invade the newly formed mountain range. Eventually the molten rock matter cools down and solidifies as granite. Erosion, attacking the mountain range thereafter, strips off the covering rocks and eventually exposes the granite core. Around high points on the granite core there may be a clustering of metal-bearing veins, and when these are found by the prospector, a new mining district springs into existence. Technically, we express these ideas by saying that ore deposits of certain kinds are related in time and space to the invasion of the earth's crust by masses of molten granite. Intrusive granites are not only common the world over but they range in age from very old—2 billion years—to very young. The earth has shown no marked decrease in its power to generate granite masses, nor has there been any enfeeblement in the ore-bringing powers of these granites; in other words, the largest and richest ore districts were not necessarily formed early in the history of our planet and smaller and poorer deposits formed as time went on. On the contrary, the world's richest metal-producing district, in the sense that it contains the greatest concentration of metals within a small area, is Butte, Montana, and the ore was formed at the beginning of geologic modern times, some 60 million years ago.

At this point we are confronted with a

great gap in our knowledge. We do not know why certain granite intrusions were productive of ore deposits and why others were sterile. New England affords us a striking example: not once, but three times during its geologic history has it been invaded by great volumes of molten granite, but all three of these invasions produced no ore—they were sterile granites. To account for the extraordinary difference among granites as ore-bearers is a major problem in theoretical geology. When this problem is solved by more research, a by-product will be a great advance in the practical art of ore discovery.

The large number of metals and minerals required in the war effort were classified in three categories: (1) strategic minerals, which are necessary but cannot be produced within our own country no matter how great the price stimulation; (2) critical minerals, which are necessary and can be produced by price stimulation, and (3) essential minerals, which are necessary and of which we have an ample supply. These distinctions are important, and as I shall attempt to show, are rooted in the fundamental geology of the substances. Tin and nickel are strategic metals, and no amount of money or political pressure can produce them from our own territory in more than minute amounts. Nickel indeed poses this unsolved problem: Why is nine-tenths of the world's known supply of nickel localized at Sudbury, Ontario, and most of the remainder in New Caledonia? Since all three classes of minerals were necessary to the war effort, these terms tended to lose their sharpness of definition; all war minerals were likely to be called strategic minerals.

Owing to war demands, chiefly in airplane construction and in incendiary bombs, magnesium developed faster than any other metal in history. Its production increased more than fiftyfold in the four years between 1939 and 1943. Five sources of raw material were available, two of which are inexhaustible (true of few other mineral resources). These two sources are sea water, which contains 0.13 percent Mg, and dolomite, which contains 13 percent, or 100 times as much as sea water. Now, the distribution of dolomite throughout the United States has long been known to geologists, and when a representative of one of the Government agencies visited Yale to find out whether we knew where there is an available supply of dolomite 99 percent pure in eastern New York or Connecticut, he was told by a geologist attached to our department that such a deposit occurs at Wingdale, Dutchess County, New York, and, soon after, a magnificent magnesium reduction plant was built and put into operation.

In response to the demands of war a complete inventory of the dolomite resources of the country was made, which necessitated accurate sampling and tonnage measurements. Although dolomite is an abundant rock, making up formations hundreds of square miles in extent, yet the number of deposits becomes surprisingly small when we demand 99 percent purity, accessibility, nearness to transportation, and availability of a large supply of electric power.

Aluminum is highly important as a war metal. Our supply of aluminum ore (bauxite) has come mainly from Surinam in South America. Early in the war submarine sinkings greatly jeopardized the flow of this ore to our country; in fact, according to Alan M. Bateman, of the Bureau of Economic Warfare, they actually succeeded in stopping the flow for a time. Our only important domestic source of aluminum ore of metallurgical grade is in Arkansas. To meet the war crisis production was stepped up in Arkansas fifteenfold: from 400,000 tons a year to 6,000,000 tons. As this rate of production would have de-

pleted the known deposits in less than two years, a vigorous campaign of exploration for more ore was begun by the Geological Survey and of verification by the Bureau of Mines. That is, the geologists predicted, on the basis of their theories of how the aluminum ore had been formed, where the ore lies under a cover 60 to 100 feet thick, and the engineers, by putting down drill holes, proved that the ore is there; this was very gratifying teamwork. In this way many million tons of ore were found. As soon as the danger of submarine sinkings was ended, foreign ore, which is of higher metallurgical grade than the Arkansas bauxite, was again imported; consequently, our own source of fairly high grade aluminum ore has been saved for postwar use. So relatively small are our known domestic reserves of bauxite, however, that it is the part of wisdom to provide reserves of substitute materials. In line with this, Congress has forehandedly appropriated large sums to the Bureau of Mines to study the extraction of aluminum from high-alumina clays and feldspar rocks. Reluctantly, I leave the subject of aluminum ore, for the principles of its origin are so well determined and the ore itself is so inconspicuous and downright unimpressive that future geologic exploration will probably discover great additions to the proved reserves of aluminum ore, if not in the United States then in the rest of the world.

Vanadium is another important war metal, normally obtained from Peru. A remarkable discovery of vanadium ore in Idaho, of a kind never found before, was made by one of the Federal geologists, W. W. Rubey. The geologist himself modestly says it was an accident, but it is one of those accidents, as Pasteur said, that happens only to the trained mind. An immense tonnage of vanadium ore has been proved to occur in Idaho. The metallurgy of extracting the vanadium has not yet been perfected, perhaps I should say fortunately, for the vanadium now remains in the ground, where it is available for a future national emergency. However, the prevalent idea is that mineral deposits should not remain in the ground. All past history shows that no known mineral deposit will be saved as a reserve for the benefit of future generations if that deposit will yield a profit by taking it out of the ground. Furthermore, the engineer can show, by the aid of the inexorable logic of mathematics, that the maximum profit is won by extracting a mineral deposit as rapidly as possible, thus converting it into money, and this money can be put into the bank where it will earn interest in perpetuity without its owner doing any further work. This logic ignores the national welfare, but money talks, powerfully.

Many other strategic and critical minerals have undergone extraordinarily interesting developments during the war, but I shall mention only the pegmatites from which mica, beryl, tantalite, and columbite can be obtained. Pegmatite is the name given to certain remarkable tabular rock masses of coarse or gigantic grain size occurring as dikes and veins around the periphery of granite masses. The largest known crystals occur in pegmatites, the world's record being a crystal of the lithium mineral spodumene 42 feet long occurring in the Black Hills of South Dakota. Pegmatites are numerous (New England is full of them), but few of them carry anything of value. Furthermore, the valuable minerals are erratically, capriciously, and unpredictably distributed throughout a given pegmatite. The result is that the mining of pegmatites is a headache; and mining corporations generally leave them alone; they leave them to be worked by the little fellow who has invincible optimism and does not mind going broke. Although pegmatites are of great interest to geologists and have been much studied, no

experienced geologist would venture, even under pressure, to forecast how much valuable mineral content any given pegmatite might have. But because pegmatites are the sole sources of vitally needed mineral commodities, the problem had to be attacked.

Mica is a top-priority mineral. Every spark plug, every motor and generator brush, and all radio condensers require mica, and no substitute has been found. Our main source is India, and for a time the mica was flown in by airplane. To stimulate domestic production, the Government set up the Colonial Mica Corporation. This corporation caused a great expansion of mining; from less than 50 mines in 1942 to 789 in 1944, but all of these were small-scale operations based on pegmatites long known, mainly in North Carolina and New England. Colonial Mica, i.e., the Government, paid on the average $6.00 per pound of mica and sold it at an average of $1.60 a pound. That amounts to a bonus of $4.40 a pound. In spite of this powerful stimulation, scarcely any new deposits of exceptional grade have been found.

Tantalum is a rare element, the demand for which has greatly increased during the war—in radio grids and for other purposes, the use of tantalum wire in surgery in sewing nerves being a remarkable development. Tantalum was imported mainly from Western Australia; now from Brazil. Columbium, which occurs with tantalum in the solid-solution series tantalite-columbite and was until recently regarded as a nuisance, is now in demand for jet-propelled planes as the only metal that will stand the high temperatures.

Beryllium is the last of this geochemical group of elements I propose to mention; it is obtained from the pegmatite mineral beryl, which is its sole commercial source the world over. Beryllium is lighter than aluminum and confers remarkable properties when alloyed with copper; it is therefore a metal of great interest. Recently, when I was in Washington, I was told that at a committee meeting, a common event in that city, a naval officer was so impressed by the accounts of the remarkable properties of beryllium that he exclaimed, "Now we will have to build our destroyers with beryllium." Alas, he had no geologic inhibitions! He was unaware, like many others, that mineral procurement is not solely a matter of technology and economics, but is ultimately controlled by geologic laws.

The Oil Situation

The impact of the war on the oil situation has been tremendous. The importance of petroleum and its products in waging a modern war was epitomized by Marshal Foch: "In war a drop of gasoline is worth a drop of blood." That remark has always seemed to me to cut like a two-edged sword: while it emphasizes the supreme importance of gasoline, it also emphasizes the infinitesimal value of human blood in modern warfare. At the end of World War I Lord Curzon said, "The Allies floated to victory on a sea of oil." Such was the recognized importance of oil in World War I. In World War II the gasoline needs at the time of writing were already 80 times greater than in the previous war. Every American soldier overseas required more than 50 gallons of petroleum products per week, and this figure takes no account of the enormous needs of the Navy nor of those of our Allies. To meet these insatiable demands domestic production has been speeded up and the output reached a new peak in 1944—1,700 million barrels (a barrel being 42 gallons)—11 percent greater than that of the preceding year.

Besides this speeding up of the oil production, other things have been done. For example, there was the Canol Project which has attracted much attention.

Why did the Army in face of much opposition back the project so firmly? The Army was evidently convinced by its consulting geologist that oil was there, and so the pipeline was constructed. At any rate, oil flowed at the rate of a million barrels a year from the field to the refinery at Whitehorse, Yukon Territory, some 600 miles distant. Despite assertions to the contrary, the oil flows even at the winter temperatures of 20° below zero F. Reserves at Canol are conservatively estimated at 60 million barrels. Private interests are exploring beyond the limits of the pool. Much larger reserves will have to be found in order to justify taking the oil to seaboard through a larger pipeline after the war.

The enormously accelerated rate at which we were compelled to draw off the oil from its underground sources is the main cause of the present concern as to the future of our oil supplies. Our proved reserves of oil, 20½ billion barrels, are the largest in the history of the industry. (By "proved reserves" we mean the oil that can be estimated with some accuracy as the result of drilling.) In the case of a particular oil field its reserves are regarded as proved if (1) the size of the field is known because sufficient bore holes have been put down to outline the field, (2) the thickness of the oil-bearing beds is known, and (3) the volume of the pore-space in these beds is known. From these figures we can compute the volume of the oil in the ground; but the recoverable oil, which is the oil that present practice can obtain at the earth's surface, is only a fraction of the oil in the ground. It is between 15 and 40 percent, depending, among other things, on the rate of recovery, which should not exceed a certain optimum rate. Consequently, an "exhausted oil field" still holds about 75 percent of its original content of oil. Colonel Seller's famous remark "There's millions in it" is a gross understatement: when the appropriate technique is devised to move this reluctant oil to the earth's surface, there will be literally "billions of dollars in it."

The wartime rate of extracting our oil is too fast for efficient operation. One way to maintain efficient operation is to find more oil fields and so distribute the load more widely. Therefore, 24,345 wells were completed during 1944, an increase over the previous year; 5,000 of these were exploratory wells. Although 1,700 million barrels of oil were taken out of the ground in 1944, the year ended with a gain of 500 million barrels of proved reserves. Unfortunately, most of this gain was the result of extensions of fields already found in previous years and therefore it cannot be considered wholly new discovery. On the other hand, the size of the newly discovered fields has been disappointingly small. The downward trend, which began in 1937, in the rate of discovery of new reserves causes the present discussion of the danger of an impending shortage of domestic oil.

It is in the finding of oil that geology has achieved its most brilliant practical results. The birthday of the oil industry of the United States was in 1859, when Colonel Drake, of New Haven, Conn., brought in the pioneer well in western Pennsylvania; that well was 69½ feet deep and yielded 25 barrels of oil a day. The boom was on! By 1861, that is, only two years later, geologists had already outlined the fundamental principles that govern the accumulation and occurrence of oil in the strata. But for nearly 50 years these geologic principles were not believed by the managements of oil companies; in fact, they greatly preferred their own theories; perhaps understandably, since certain powerful geologists, such as J. P. Lesley, strongly opposed the acceptance of the prevailing geologic explanations. However, after the turn of the present century accep-

tance was rapid and practically all oil companies now have geologic staffs; in fact, oil geologists are by far the most numerous of the species, the American Association of Petroleum Geologists alone enrolling 4,000 of them. Recently two exploratory wells, one in California and the other in Texas, attained depths exceeding 16,200 feet—considerably more than 3 miles! This achievement measures not only the great technological advance that now makes it possible to bore to this extreme depth, but also the strong conviction necessary to plan and to carry out such a project; a deep well of this kind costs $600,000 to $800,000 or more, and no oil company would expend such sums except for powerfully logical or—dare I say—geological reasons.

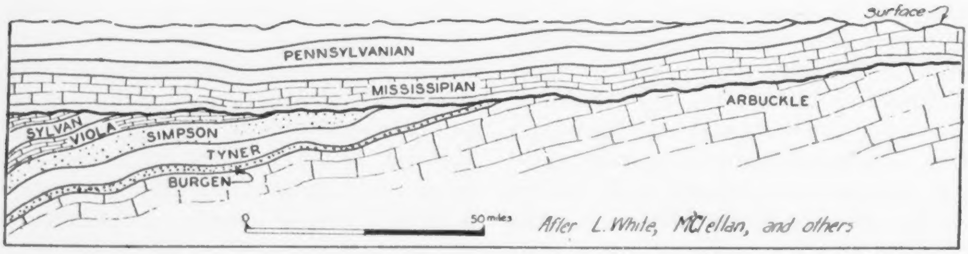
I have already mentioned that the amount of new oil discovered since 1937 has been disappointingly small. So far a total of more than 3,000 oil fields have been found in the United States; of these, 100 rank as major fields. By a major field we mean one from which the total oil produced will exceed 100 million barrels; and it is the great falling off in the number of major fields discovered that is causing so much concern. The rate of discovery has not fallen off for lack of exploratory drilling, for the amount of wildcatting, as the industry calls it, is as high or higher than it ever was. In the mining industry wildcatting is a term of great opprobrium, but in the oil industry it is one of high esteem. A wildcat is an exploratory hole drilled completely outside of known fields. About 75 percent of all wildcats are now drilled on geologic advice and the other 25 percent are drilled for nontechnical reasons; on "hunches," "doodlebug" indications, and for other equally recondite reasons; 20 percent of the holes drilled on technical advice are successful, as shown by statistical evidence, whereas only 4 percent of those located without technical advice are successful.

The problem confronting us is to find oil fast enough so that our reserves will not be required to produce beyond the maximum efficient rates. It must be pointed out that no method yet devised, geologic or geophysical, finds oil directly; what is found by the oil-hunting methods is a likely trap, or reservoir; but until the reservoir rock is actually perforated by the drill no one knows whether it contains oil.

Additional reserves of oil within the United States may be sought (1) in regions that have not yet been thoroughly examined, but of such territory little is left, so intensive has the search been; (2) in strata much deeper than those in which oil has already been found, as indicated by the steadily increasing average depth of exploratory holes, now between 4,000 and 5,000 feet deep; and (3) below an unconformity in a second layer of geology, in which the oil occurs in an entirely different way from that in the overlying layer.

In the accompanying figures such "layers of geology" are shown in profile. Figure 1 gives a cross-section through a region in which two such "layers of geology" are present, in each of which the oil occurs according to different rules. Manifestly, the oil in the lower layer is a very effectively concealed resource. Figure 2 shows a still more complex condition, in which there are three superposed layers of geology, each characterized by its particular mode of occurrence of oil; and Figure 3, which illustrates in a general way the conditions in northern Louisiana and southern Arkansas, shows four superposed layers, each separated by an unconformity. Each unconformity, in brief, represents tilting of a series of strata and uplift above sea level, beveling by erosion, submergence of the beveled strata beneath the sea, and the deposition of a new series of strata on the surface worn across the older strata.

Other valuable mineral resources may



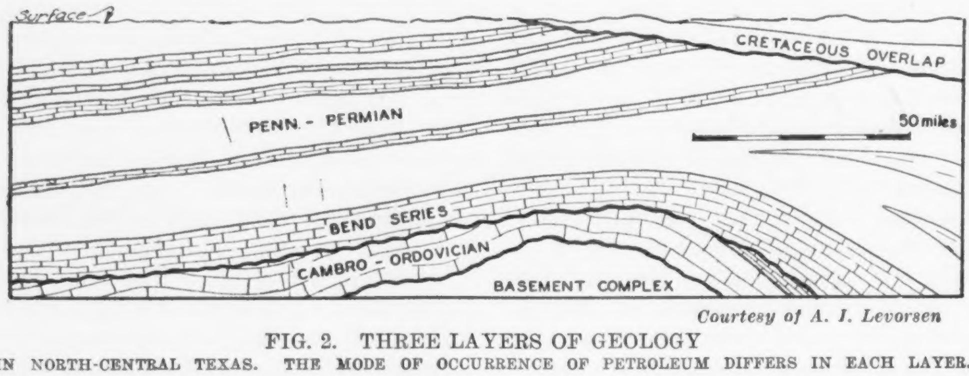
Courtesy of A. I. Levorsen

FIG. 1. TWO LAYERS OF GEOLOGY
IN SOUTHEASTERN KANSAS AND NORTHEASTERN OKLAHOMA. THE TWO LAYERS ARE SEPARATED BY AN UNCONFORMITY (HEAVY LINE); THEIR GEOLOGY (PETROLEUM AND GENERAL) DIFFERS GREATLY.

be concealed below an unconformity, as illustrated by the famous United Verde copper deposit in Arizona. From left to right, Figure 4 shows five stages in the geologic history of the deposit: (1) the ore body as it was shortly after it was formed in Precambrian time, more than a half billion years ago; (2) slicing of the ore body into two segments along a fault and separating them by 2,400 feet; (3) erosional reduction of the area in which the two segments occur to a flat surface; (4) deposition of limestone on the outcrops and subsequent flooding by basalt lava; and (5) present condition, in which one segment of the ore body is exposed at the earth's surface and the other segment, which is below the unconformity, remains concealed under a cover of limestone and basalt. The exposed ore body, the United Verde, one of the largest pyritic copper deposits in the world, was found in the early eighties, but more than 30 years elapsed before the concealed ore body, the United Verde Extension, was found. The finding of that bonanza ore body in 1914 is significant in another respect: it is the only major discovery of copper ore in the United States during the past 40 years.

To return now to the matter of the undiscovered oil reserves. Finally, undiscovered oil may occur in what are termed stratigraphic traps, few of which, in the light of present scientific knowledge, can be found by rational methods. In fact, the greatest of all oil fields, the East Texas field, in which the oil is in a stratigraphic trap, was discoverered by pure wildcatting.

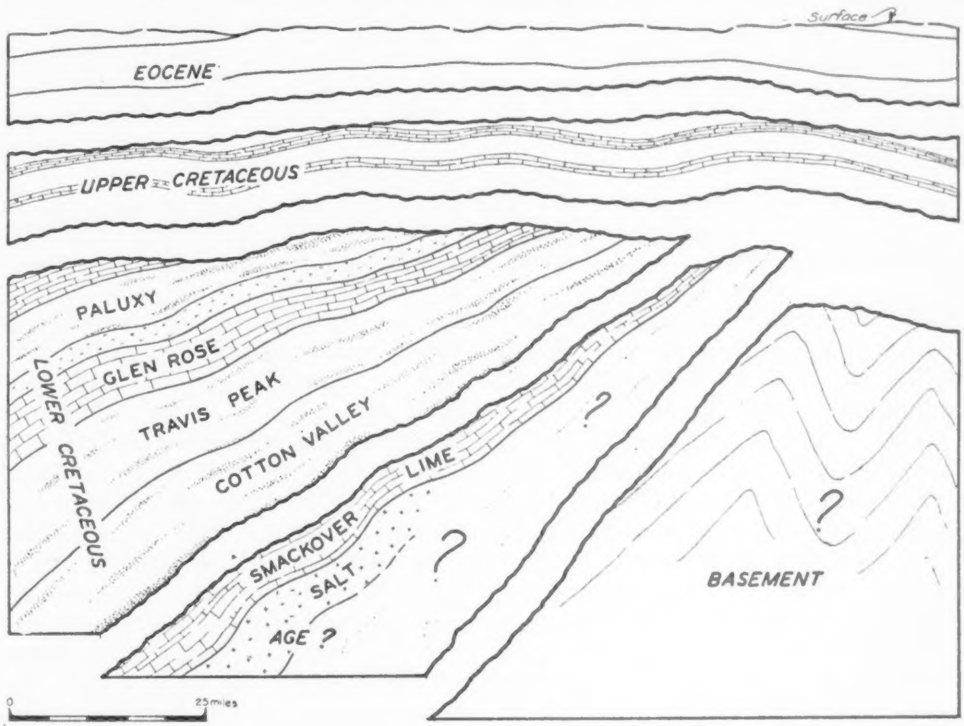
In the last two decades geophysics has been enlisted in the search for oil. The seismograph, the gravity meter, the magnetometer, and the galvanometer are the chief instruments used. Geophysical methods are a form of geologic explora-



Courtesy of A. I. Levorsen

FIG. 2. THREE LAYERS OF GEOLOGY
IN NORTH-CENTRAL TEXAS. THE MODE OF OCCURRENCE OF PETROLEUM DIFFERS IN EACH LAYER.

tion. All of the geophysical prospecting methods "suffer from the disadvantage that they measure only differences in physical properties and do not reveal directly the presence or precise nature of the deposit under consideration." If no geologic information is available in regard to an area that is being prospected by geophysical methods, the geo- minishing returns has already begun to operate. It is therefore the conviction of leading petroleum geologists that what is urgently needed in order to find the undiscovered oil is more geology, "but on a much higher scientific level than heretofore." In short, not only the easily found oil fields have been discovered, but also many that required



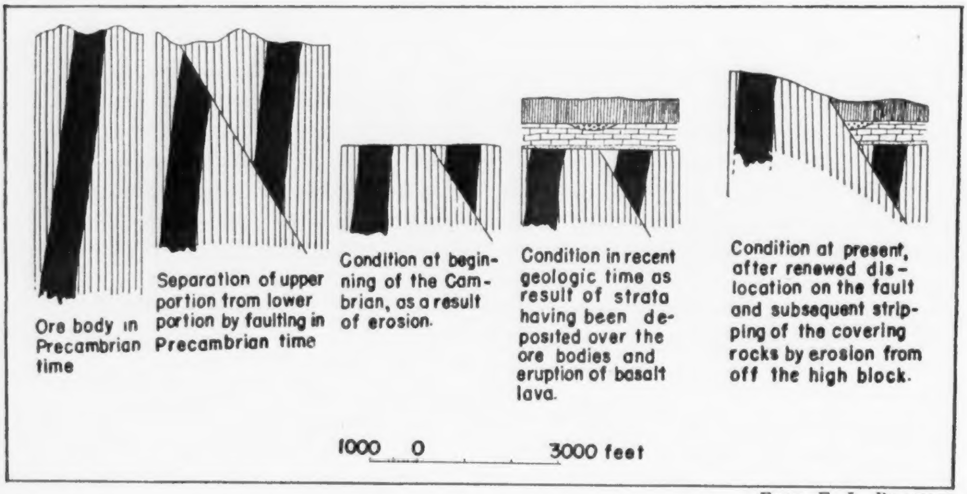
Courtesy of A. I. Levorsen

FIG. 3. FOUR LAYERS OF GEOLOGY

IN NORTHERN LOUISIANA AND SOUTHERN ARKANSAS. IN THE DIAGRAM THE LAYERS HAVE BEEN SEPARATED ALONG THE UNCONFORMITIES FOR THE SAKE OF CLARITY. IN THIS SEQUENCE OF LAYERS, AS IN THOSE SHOWN IN FIGURES 1 AND 2, THE UPPER LAYERS DO NOT SUGGEST THE NATURE OF THOSE BELOW THEM AND EACH LAYER MUST THEREFORE BE PROSPECTED DIFFERENTLY.

physical results can be interpreted in several different ways, but if something in regard to the geology is known, the interpretations are thereby restricted. Consequently, the success of these methods depends on how closely geologists and geophysicists collaborate.

Brilliant results have been obtained by geophysical methods, but the law of di- extraordinary skill. Finding the remainder will require a greatly improved "art of discovery," which should inevitably result as a by-product of more research. The oil companies have large forces of geologists and geophysicists engaged in searching for oil, however. Nevertheless these men must concentrate their efforts on what appears likely to



From F. L. Ransome

FIG. 4. EVOLUTION OF A COPPER DEPOSIT

SUCCESSIVE STAGES SHOWING HOW A DEPOSIT BECAME CONCEALED BENEATH AN UNCONFORMITY.

bring immediate results, and therefore their attention is focused on relatively small areas. Scientific advances are incidental and accidental. Because of the vital importance of the petroleum supply to the nation, the U. S. Geological Survey has begun a nationwide investigation of all the regions that are probably or possibly oil-bearing. This investigation is based on fundamental principles and is planned as a long-range campaign.

Fundamental to such a long-range campaign is the making of a geologic atlas of the whole United States, comprising more than 13,000 individual maps on a scale of one or two miles to the inch, or even larger scale for districts of particularly complex geology. On these maps will be shown all the formations that underlie the subsoil. Such maps, experience has proved, are the indispensable foundation for all further scientific research, as well as for the more material purposes of finding concealed mineral resources. The best brief explanation why such maps are indispensable is that maps on the large scale of the individual units can be combined and recombined into successively smaller scale maps, and from these the observer can obtain, as it were, a bird's-eye view of the geology of a regional unit. Broad relations thereby become visible, and penetrating deductions become possible.

So far only 15 percent of the area of the United States has been geologically mapped on an adequate scale. That leaves 85 percent yet to be surveyed: we can therefore say that our main work is still ahead of us.

JOHN ERICSSON

By OWEN JOHNSON

How estimate the age of a man? By the years to his death? Or by the way those years have been lived? When we cease to produce we begin to die. By 50 the great majority of men are not so much living as gradually dying—pleasantly, quite unconsciously—but still dying. I know a few who have been plodding the outward trail from a much earlier period. True, some tragic figures at 30 (and how many will come out of this war?) have lived through a dozen lifetimes. Michael Angelo, Leonardo da Vinci, Darwin—such men, by their driving power of creation, double or triple their generous span of life.

To say that John Ericsson lived 86 years would be an understatement. By his complete concentration on his work he crowded into his long life the efforts of three or four average workers. He died in full possession of his faculties. For the last 40 years he had worked 14 hours a day every day of the year, completely happy, completely absorbed. He may well be said to have lived out two centuries.

He lived his life as though it were a race against time, jealous of every hour he had to divert from his workroom. He had no time to spare for the adulation showered on him in the final triumphant years. No time for the distinguished visitors who begged in vain for an interview with the inventor of the epoch-making *Monitor* and the revolutionary screw propeller. No time even for his wife, his friend and admirer to the end, who gave up the unequal struggle and returned to her native England.

"She was jealous of a machine," he said laconically. Even to his few intimate friends he grudged a quarter of an hour's interview.

"Your time is up," he was wont to say. "Now you must go."

His drafting room was his castle, from which his vision soared outward across the great uncharted future of science. So little had been done—so much lay ahead and so little time! If he could have 50 years more, 20 — 10! Even when he needed a short nap he refused to leave his monastic cell, stretching out on his drafting board with a book for his pillow. In all his years in New York he never saw Central Park and only once set foot on Brooklyn Bridge, and that by a trick of a friend. Once Delameter, his closest associate, fearful for his health, tried to inveigle him into a trip to Niagara Falls.

"What's wrong with them?" he asked, not without a certain grim humor. No other reason could justify the loss of a working day.

He died a figure of world dimensions. The country of his adoption paid him the signal honor of conveying his body with full military honors to the country of his birth, which for a generation had clamored for his return as a national hero.

Everything about Ericsson's life had a touch of the dramatic, even to the month of his birth: July 1803. For in that same month Robert Fulton was conducting his first experiments with his paddle-wheel steamer on the Seine, little dreaming that a genius was born who would nullify all that he was creating.

It was a dramatic century which had just begun, the era of accelerating speed of which the end is not yet in sight. The speed of locomotion had been static since the dawn of civilization. The world was still jogging along on land at a pace of six miles an hour. On sea the winds and their caprices still ruled, as they had since the days of the Greeks and the Phoenicians. Galileo had cut the dis-

tances to the stars but the great oceans still held their barriers against the races of men. When Ericsson died in 1889 the conquest of terrestrial space was in full sway, largely due to his contribution of the revolutionary motive force of the screw propeller. Today this one physical achievement has wrought social and political evolutions which have determined the whole future course of civilization.

Never once through 40 years of persisting adversity was Ericsson's confidence in himself shaken. No failure, no ingratitude of nations, no ridicule from his own profession was able for a moment to sway him from the destinies he knew were in him. And the key to his character is in the drama of his boyhood.

He was blessed with three gifts: poverty, the greatest spur of all; isolation from the conforming influence of the crowd, and the imperative necessity of securing his own education. His parents were of good average stock living a pinched existence. He was born at Filipstad in the Viking land of the northern mines of Sweden, within six degrees of the Arctic Circle. These were primitive surroundings, where men looked inward for their strength and reliance, and where in the deep silences of long nights to dream was instinctive.

Where other children played with toys, he was fascinated by machines. When he was only seven he haunted the drafting room of the great Gotha Canal where his father was a foreman. There was no money to supply him with proper instruments for mechanical drawing, so he constructed them himself. He made a compass out of pine twigs and inserted needles; a drawing pen from tweezers sharpened to a point, controlling the thickness of the line by a thread which could be slipped up and down. To color his drawings he mixed his own pigments. He made two small brushes from hairs discreetly plucked from his mother's sable coat. With these tools the child sat long hours at his drawing board, drawing to scale. At the age of nine he was ready for the first great adventure.

He determined to construct a model of a sawmill. He had never seen one. All he had to guide him were descriptions supplied by his father. Nevertheless the young engineer drew his plans and made his precise calculations. He had only a gimlet, a jacknife, and a file. It was not a boyhood toy he evolved but a complete working model. The wooden frame was constructed to a calculated scale. For a saw, he took a watch spring and filed out the teeth. Everything was complete in miniature; the bed to carry the logs, moved by a cord wound around a drum, the ratchet wheel and lever to turn the drum, the crankshaft, and a lever fashioned out of a broken spoon. When it was completed to the last detail he hurried to a brook to put it to the test. Would it work? Had he missed one necessary detail? In all the after years, even at the height of his fame, probably no moment ever exceeded the thrill that came to the boy of nine as the wheels turned with the current and every detail functioned in perfect harmony.

The next year, at the age of ten, he constructed an even more complicated model, a pumping engine to draw water from a mine, the motive force supplied by a windmill. To the original model he later added a ball-and-socket joint to adapt it to the shifting of the wind. As with the sawmill, all the descriptions had been supplied him by his father. Both models had been so expertly planned and constructed that they needed only to be reproduced on a larger scale to function practically.

Years later, when Ericsson was asked for a list of his more important mechanical achievements, these boyhood models headed his list. He made no mistake in his estimation of their importance to his career. From these early victories, he acquired an unshakable faith in himself.

A legend began to form about him.

Men in high places interested themselves in his future. Before he was 14 he was employed as a leveler in the construction of the Gotha Canal. Six hundred Swedish soldiers worked under the direction of a boy still so small that he needed a stool to reach the eyepiece of his leveling instrument.

Meanwhile he continued his self-education. He never attended school or college, but he absorbed knowledge hungrily from anyone who could help him. Down to the last detail all his inventions were planned and drawn out by himself. Without this ability as a master draftsman he could never have constructed his first locomotive in seven weeks or accomplished the amazing feat of building the *Monitor* in 100 days from the laying of the keel.

During this period, always interested in the theories of motion, he became fascinated by the obliquely applied stroke of the bird's wing and the propelling power that lies in the tail of the fish. From these observations of nature's forces he evolved his conception of motive power applied through a screw propeller.

A second observation affected the conception of the *Monitor*. He watched the floating rafts of logs on the lakes and noticed their unusual stability in storms which overturned or sank other boats. From this memory he evolved the low flat deck of the *Monitor*—which was in fact what it was derisively dubbed, "a cheesebox on a raft."

So ended a brilliant and precocious youth. No one who knew him had any doubt of the great things he would accomplish. Yet for almost 30 years, despite a series of brilliant accomplishments, the full measure of success was denied him.

Ericsson's intention was to establish himself permanently in England; without two dramatic failures he would never have sought the shores of America. He had not succeeded in an early attempt to introduce a flame machine which, though it had worked satisfactorily under wood fueling, was not adapted to the use of coke. His prolific imagination, however, was turning out four or five important mechanical inventions a year. When he was 26, after he had been in London three years, there occurred the first dramatic test of his career.

Three-quarters of a century after Watts' experiments with steam, only a few crude locomotives had been built. They were used to draw heavy freight for short distances at no more than three to four miles an hour. After years of hesitation the Liverpool and Manchester Company succeeded in securing a charter to build a railroad. It immediately announced a prize of £500 for a locomotive which must attain the speed of ten miles an hour, weigh no more than ten tons and draw twenty tons seventy miles. Ericsson learned of the contest when but seven weeks of the allotted five months remained. He had never built a locomotive, and he would not have time to test it. Undaunted, he began work at once.

The contest took place over a two-mile stretch of railroad, and it was necessary to make twenty round trips. There were five entries but the contest narrowed down to George Stephenson's "Rocket" and Ericsson's "Novelty." Ericsson was supremely confident, for he had equipped his engine with a forced draft to produce high speed and had ingeniously suspended it on springs so that it held the track without the slightest swaying motion.

It did develop a speed of well over thirty miles an hour—the fastest that any human being had ever moved! On the first day of the trial the "Novelty" shot by the "Rocket" like a projectile. For one dramatic moment the young engineer felt the thrill of a triumph that would have made him the greatest figure in the mechanical world. But on the third trip the untested boiler proved too

weak to contain the great power of the steam generated. It was a defect that could have been easily remedied.

But there was no going back on the decision of the judges. Stephenson and not Ericsson became the father of the modern locomotive. For his successful rival, Ericsson retained a high esteem. And philosophically he came to regard his own defeat as all for the best. Had he reached world fame at the age of 26, he said, he probably would have created nothing further. As it was, he turned to a new field.

Ericsson saw clearly the limitations of the paddle-wheel steamer. For naval combat is was obviously vulnerable. For commercial purposes it was cumbersome and limited in speed. It could move directly into the wind, it is true, but even under favorable circumstances it could develop a speed of only four to six knots. Childhood observations on the movement of birds and fish remained in his memory. Gradually he perfected the principle of the screw propeller. Other minds in Austria, France, and the United States had played with the same idea, but Ericsson was the first engineer with the knowledge and experience to bring a theory into practical realization. The screw propeller, as developed by him, revolutionized the ocean commerce of the world. Yet for years, even after the first demonstration of its efficiency, it was fiercely fought as both impractical and visionary. It is difficult today to realize the opposition to new ideas against which that generation of great engineers had to contend. The explanation, however, is simple. A revolutionary idea is not only a creative force, it is essentially a destructive one. For that reason every world-transforming invention has had to contend against the vested economic order—both capital and labor.

Ericsson was now ready a second time to challenge the old order, and a second time he met with defeat. In 1837, at the age of 34, he was ready to demonstrate his screw propeller to an incredulous world. This time he was absolutely confident of success. He had had the time he needed to complete every test. To the last detail he had guarded against the possibility of failure.

He invited the Lords of the Admiralty to the first public demonstration. He had installed below the water line in the stern of the *Francis B. Ogden,* a vessel of 45 feet in length, his twin screw propellers. Already the boatmen of the Thames had been so mystified at the sight of this steamer moving swiftly and mysteriously along the river that they had named it "The Flying Devil." On the appointed day Ericsson repaired to where the Lords of the Admiralty and a distinguished company were waiting. Unfortunately they did not come with open minds; their verdict was already established. They had listened to the engineering corps of the nation, which was arrayed unanimously against this ridiculous invention constructed "on erroneous principles and full of practical defects."

The *Ogden* effortlessly and smoothly, moved by the unseen propellers, towed a barge up the river and back without in the least shaking their convictions. They disembarked with a few perfunctory expressions of thanks for the "interesting" experiment. Not one had the slightest suspicion that he had taken part in the first successful demonstration of a new motive principle destined to revolutionize sea power and relegate to oblivion the ponderous side-wheel steamers they were so obstinately defending. And the reason for the rejection? It was solemnly pronounced that "if the power was applied at the stern it would be absolutely impossible to make a vessel steer!" A second time Ericsson had stood on the brink of fame and seen it denied him.

Ericsson now went through a period of such utter poverty that he was actu-

ally imprisoned in Fleet Street, the debtors' prison. Completely discouraged, he abandoned the country which had twice misunderstood him and sought his career in a land that seemed to welcome new ideas. This was in 1839 and he was now 36. Had the result been different, his luck in England better, Ericsson undoubtedly would have remained there at the top of his profession, and the *Merrimac* without opposition would have swept the sea and ravaged the ports of the North. On such obscure vicissitudes are the destinies of men and nations fashioned.

ERICSSON came to America with the highest hopes. Americans had recognized the value of the screw propeller. Americans had insisted on the opportunities that lay before him in the New World. He believed that his troubles were now over. Unfortunately they were just to begin. His mind was so prolific that he was able to establish some financial independence by the invention of a steam fire engine and a hot-air or "caloric" engine.

But in the development of the screw propeller for naval vessels, on which his heart was set, he met only with discouragement and disappointment. It was five years before the Naval Board was willing to make a test. When the *Princeton,* the first man-of-war to be equipped with a screw propeller, was finally contracted for, it was done under such humiliating conditions that Ericsson felt he had been betrayed. His contribution was minimized. Even the payment for his services was disputed by the Government and was never made. And on a trial trip, through no fault of Ericsson's, one of the *Princeton's* big guns exploded and killed the Secretary of State, the Secretary of the Navy, and other high officials gathered to witness its triumph.

For almost twenty years defeat, discouragement, and adversity pursued him. Even the credit for his invention was for a long time denied him. A new venture into his favorite field of the hot-air engine ended in a fantastic disaster. The ship equipped with the new engine was struck by a tornado on its trial trip and sank. Pecuniary difficulties beset him a second time, and he lacked the commercial sense to capitalize on his inventions. Yielding to a momentary discouragement, he now considered abandoning the struggle in America and returning to Europe. Fortunately for the North he reconsidered and remained to play his decisive part in the history of his adopted country.

WHEN the fateful year of 1862 arrived Ericsson was still struggling for recognition of his greatest achievement. He was beset with litigation over his claim to fame as the inventor of a screw propeller. Imitators abroad copied his mechanical devices or openly stole them. The invention in which billions are invested today brought him no change in fortune. A few men recognized him as the engineering genius of the time, but outside these he was still meeting hostility in his own profession, and a large section of the scientific world condemned him as a mountebank and a visionary.

It was known that the Confederates were completing the construction of the ironclad *Merrimac,* and yet nothing had been done in the stagnant naval circles at Washington to meet the threat of destruction of the wooden ships of the Federal Navy. Fortunately the *Monitor* did not have to be created. The plans had been perfected for years. As far back as 1854, Ericsson had offered to Napoleon III a completed model which, with the exception of one unimportant detail, was the exact working model of the *Monitor.* In it he had perfected his conception of an ironclad ship where all vital parts would be below the water line. It had a flat raft-like deck with the firing power concentrated in a revolving tur-

ret, which would permit the guns to be reloaded in security instead of being exposed to enemy fire.

Despite the shabby treatment he had received at the hands of the Government in the matter of compensation for his work on the *Princeton,* Ericsson loved the country of democracy. He wrote to Lincoln offering his services, stating that he sought "no private advantages or emolument of any kind." He maintained this attitude to the end.

He presented before the Naval Board at Washington a replica of the model which had been offered to Napoleon III. Lincoln was impressed and threw his weight in its favor. The opposition remained violent and unconvinced. One member scornfully remarked: "Take the little thing home and worship it, as it will not be idolatry because it is in the image of nothing in heaven above or on earth beneath or in the waters under the earth!" The contract had been actually rejected, when Ericsson appeared before the full board and made such a convincing exposition that the decision was reversed. But the Navy insisted on inserting a clause guaranteeing refund to the Government of all money paid out in case the vessel proved a failure.

The *Monitor* was built in 100 days from the laying of the keel. It was accomplished despite tardy payments from the Government (the battle of the *Monitor* and the *Merrimac* was fought before the final payment was received), despite continuing criticism and interference of naval authorities.

Ericsson, the old Viking, refused to give an inch. He made the drawings himself, answered every criticism personally, fought off all interference and delivered the vessel on time. Inside the ship were more than forty patentable devices which he had turned out in the full flush of his genius. At the first trial a slight error developed in the steering apparatus. The naval authorities, alarmed, advised putting the ship in drydock and fitting a new rudder. Thereupon Ericsson exploded.

"They would waste a month in doing that. I'll make it steer in three days." He did it in less than that and the *Monitor* arrived at Hampton Roads in the nick of time to fulfill her rendezvous with destiny.

Despite timidity in Washington, which insisted that the *Monitor* fight a defensive battle and would not permit it to pursue the wounded *Merrimac;* despite failure to use the wrought-iron shot which Ericsson insisted would have penetrated the armor of the enemy; despite the plan of battle, which was fought at a distance contrary to the directions of Ericsson, there was no question of where the victory lay. The first shots from the *Monitor* had in truth sunk the wooden navies of the world. The commander of the *Merrimac* himself testified before a naval court that the *Monitor* should have sunk his vessel in fifteen minutes. Later he added, "Ericsson is a great genius."

World recognition now came to Ericsson at the age of 59. Without the dramatic appearance of the *Monitor,* the ironclads of the Confederate navy would have mowed down the wooden battleships of the Union, devastated the seaports, lifted the blockade, and quite possibly have secured European recognition of the Confederacy. And all this depended on the vicissitudes in the life of one man, on two outstanding failures, without which he would never have been in America to emerge as the instrument of Providence.

The revolving turret in every battleship today is a tribute to the memory of Ericsson. His principle of screw propulsion still remains as the central principle of motive force, not only on the sea but in the skies themselves. The *Monitor* wrote his name indelibly in American history, but the screw propeller places him in the ranks of the great pathfinders who have affected the history of civilization.

RUBBER, HERITAGE OF THE AMERICAN TROPICS

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SHORTLY after 1510 Pietro Martyre d'Anghiera, chaplain in the court of Ferdinand and Isabella, wrote the preface to a still unfolding chronicle, relating in impressive Latin how the Aztecs played with bouncing balls made "from the juice of a certain herb." There are few products whose history reflects the recent changing facets of developing civilization as vividly as does that of the substance of those Aztec balls. Rubber is a constituent of latex, a milky substance formed in specialized vessels or cells in many different plants of widely separated families. In spite of a good deal of research, its role in the growth and life of the plant which bears it remains a mystery. To man, uses for rubber are multitudinous and, in both peace and war, highly essential. The development and expansion of these uses mirror faithfully the effects of the industrial revolution. The Indian discoverers utilized the substance in several ways; the conquering whites added a few others. Before 1600 the Spaniards in Mexico were dipping capes into latex to waterproof them. But nobody then really got excited about its potentialities. It took the age of machines and motion to give prominence to the stuff.

Rubber's first effective press agents were Charles-Marie de La Condamine, an exploring scholar sent forth by the Paris Academy of Sciences to make a meridian measurement on the Equator in an attempt to settle whether the earth was a flattened or elongated sphere, and his friend, François Fresneau. These two men furnished Europe with descriptions of the uses and preparation of rubber, samples of the material, and details of the botanical characteristics of the trees tapped by the Indians. La Condamine made important early observations on both rubber trees and the cinchona tree, source of quinine. Ever since, the products of the two trees have been strangely parallel in development. Both came to occupy important places in the list of man's needs; the two industries were transported to the East to be greatly expanded and lately conquered by Japan; the war years have seen heroic attempts to re-establish both in the Western Hemisphere and rapid strides in the synthesis of substitute products.

Rubber's advertising campaign really got under way about the middle of the nineteenth century. Priestley had named the stuff *India rubber* in 1770 after discovering that his sample, actually from India, would rub out pencil marks. In 1823, Charles McIntosh found a solvent for rubber in naphtha, thus making manufacturing a real possibility. Previously only fresh latex could be used, and the factories had to be almost under the trees which produced it. Still, however, one's boots and coat cracked in the winter and oozed and stuck in the summer. Then, in 1839, Charles Goodyear mixed rubber, sulphur, and heat and invented the vulcanizing process. The cornerstone was laid. New uses were developed and demands rose. More plants were sampled; great areas were explored.

Latex production is a characteristic of hundreds of plant species. The number whose latex contains rubber of acceptable quality and in significant amounts is much smaller. Discovery of this fact

soon focused the main efforts of the wild-rubber collecting industry on the Central American rubber tree, *Castilla elastica*, and other species of *Castilla* from Mexico to Bolivia; the Pará rubber tree, *Hevea brasiliensis*, and other species, particularly *H. benthamiana* and *H. guianensis*, in the Amazon region; the Ceará rubber tree, *Manihot glaziovii*, and species of *Sapium* in Brazil; Kickxia, *Funtumia elastica*, and various species of *Landolphia*, *Clitandra*, and *Carpodinus* in Africa; and *Ficus elastica* in India, Burma, and the Malay Archipelago. The most rubber and that of the highest quality came from the Pará rubber tree, and the Amazon region gained first place among rubber-producing areas. In 1827 rubber was collected only around Pará, enough to make an export total of 31 tons. In 1856 Brazil exported 2,607 tons. Credit Goodyear's vulcanizing process. The increase was steady until 1912, when a peak Amazonian production of 45,067 tons was reached. The saga of exploitation of trees and men involved in the expansion is a fantastic one depicting remarkable strides against jungle country, great fortunes built in a year or two, ravaging tropical diseases, and decimation of whole populations. In wealth, glory, and blood it is matched only by the Congo rubber operations, which supported a Belgian empire. The decreases in yields caused by overcutting of Hevea during tapping and the actual destruction of Castilla by the felling method of tapping rapidly lowered the output of certain areas and aroused grave concern over future supplies of this increasingly important commodity.

In an attempt to find ways of alleviating the predicted shortage, President McKinley, who had been a Congressman from the Ohio district including Akron, suggested to Congress in 1899 that rubber planting be undertaken in the Philippines, Hawaii, and Puerto Rico. The President was giving expression to the oft-recurring hope that we might bring at least a considerable part of the Nation's rubber supply under our own control. Inadvertently he gave incentive to a great gambling game in which many of the bets were fraudulent and most of the rest were on the wrong tree. In the decade following delivery of the President's advice, New York school teachers, Chicago policemen and letter carriers, and a host of other Americans, hopeful or just gullible, invested $75,000,000 in real or imaginary rubber plantations. The real ones covered large areas in Mexico and Central America and actually contained more than 30,000,000 trees, nearly all, as it turned out, the wrong species. Except for a few small plots, the plantings were Castilla, native to the area. As a rubber producer Castilla is second rate. Its rubber, as commonly collected and prepared, is inferior in quality to that of Hevea, and the trees can be tapped only two or three times a year; thus, while the yield per tapping is considerably above that of Hevea, the annual yield per tree is but a pound or two as against 5 to 10 or even 25 pounds for selected Hevea. Nevertheless, a highly significant proportion of the world's rubber came from Castilla during the early years of this century when the plantation rubber industry of the Far East was in its infancy. Some of these plantings still survive, and a few have yielded a little rubber now and then, but their total production has been inconsequential.

Meanwhile, the British had stolen the march. Spurred by Thomas Hancock and other rubber manufacturers and by the desirability of developing their vast tropical holdings, there rose an intense interest in attempting to establish plantations of Hevea, whose high yield of excellent rubber was bringing wealth to Brazil, in tropical areas under Her Britannic Majesty's flag. The prime

figures in bringing action in the hemisphere exchange were Sir Clements Markham, a geographer and India office official who had engineered the transfer of cinchona from Peru to India and later was to be rewarded with a knighthood; James Collins whom Markham commissioned to study the rubber situation; Robert Cross, one of Markham's quinine explorers; Henry Wickham, an enterprising Amazon planter; and Sir Joseph Hooker, foresighted director of Kew Botanical Gardens. The results of Collins' survey of the situation, containing pertinent observations of Richard Spruce, another quinine explorer engaged in botanical collecting for Kew, were published in 1872. The next year Collins bought 2,000 rubber seeds for $27 and shipped them to Kew. Spoilage of the large, oily seed was great; out of the lot only a dozen germinated. Half were kept as specimens at Kew; the rest were dispatched to the Royal Botanic Gardens in Calcutta, where despite the staff's best efforts they promptly died. In 1875 Wickham made two unsuccessful shipments of seed to Kew. The following year this practical-minded gentleman resorted to more extreme measures and, as Bekkedahl pointed out in his article on *Brazil's Research for Increased Rubber Production*, which appeared in the September 1945 issue of THE SCIENTIFIC MONTHLY, succeeded. It was the season of the Hevea seed fall, and the liner *Amazonas* of the newly inaugurated Liverpool-Amazon service lay in the upper river without a return cargo. That was too good an opportunity to pass up, and Wickham chartered the boat and set off up the Tapajós to collect all the seed he could. Thoroughly familiar by now with the perishable nature of the seed, he treated them with tender care, finally packing them in openwork baskets between layers of dried banana leaves. The baskets were carried in canoes to the *Amazonas* waiting at the junction of the Tapajós and the Amazon. Once on board Wickham began to worry about the possibility of delays in obtaining port clearance at Pará. Brazil's neighbors had been greatly incensed at the cinchona snatch, and Brazilian officialdom was reputedly much concerned over the attempts to repeat the deal with Hevea, its near-monopoly crop. Though Brazil had no law prohibiting the export of seed, Wickham supposed that he might encounter delay with what he now knew to be a spoilable cargo. To circumvent the possible difficulty he listed his shipment not as Hevea seed but as delicate botanical specimens consigned to the Royal Botanic Gardens. No delay was encountered, and he was off on a speedy voyage. At Kew the seed germinated well enough to give about 2,700 plants. Markham and Hooker decided to attempt to establish the seedlings around Tenasserim in southern Burma, but economic considerations led them to change their plans and dispatch most of them to the Botanic Garden at Ceylon. Meanwhile, Cross had started to Brazil to collect more seed, which was likewise sent to Kew for germination. These seedlings then also went to the East. Out of these early collections of Wickham and Cross, seedlings were sent to Ceylon, Java, Singapore, and Perak. Later, more seedling shipments and distribution of seed from the first importations spread trees through Malaya, Borneo, Burma, and parts of India and even the West Indies. The introduction was followed by three decades of observation and experimentation and relatively little further planting. During this period *Ficus elastica* was planted instead of Hevea, and opinion still generally favored use of this species. However, important advances were made in the development of cultural practices and especially tapping methods. The newly developed tapping, based on the so-called "wound response"

EXPERIMENTAL TAPPING
RUBBER-YIELDING CAPACITY OF HEVEA TREES IS DETERMINED BY TEST-TAPPING YOUNG TREES.

of the trees, brought Hevea's superiority to light. Important, too, was introduction of the use of acetic acid in coagulating rubber in the latex, a great advance over the primitive smoking method of the Western jungle natives. Restricted probing of various areas revealed many possessing the conditions essential for Hevea cultivation, deep soil, friable and fairly rich, and a warm climate, rather consistently moist with a rainfall in excess of 70 inches a year and without destructive high winds. By 1900 the stage-set was pretty well worked out. The curtain rise came shortly. Brazil began economic maneuverings designed to increase output and price. By 1905 the price hit $1.50 a pound. The British and Dutch responded by pouring capital, cautiously at first and then in wildcat fashion, into plantation development in their Eastern holdings. Thousands of failing coffee plantations in Ceylon and Java were quickly converted to rubber. When the price should have come down it continued to rise, for the automobile, the most important factor in the whole rubber picture, was on its way. By 1910 the American output of automobiles had reached 180,000 a year. Rubber production had risen to 70,500 long tons, 8,200 from the new plantations. Buyers paid an average of $2 a pound and once had to go to $2.88. Fortunes were made. More plantations were established. By 1914 plantation production exceeded wild collections, and at about the same time production came nearer in line with demand. The price began to decline. With falling prices the plantation system and its controlled organization had all the advantages when it came to cutting costs. The result was that the plantation growers captured and held the lion's share of the market while Brazil's native rubber industry nearly vanished. World War I and its aftereffects temporarily revived it, but by the early 1930's it had sunk to less than 10,000 tons a year, out of a world total of around 1,000,000. In 1941, 97 percent of the production of 1,527,820 tons came from the Eastern plantations, while wild rubber from South America, Africa, and all other sources, including Mexico's guayule, made up only about 45,000 tons.

The plantations then totaled about 8.5 million acres, about three-eighths of them in Malaya, a slightly smaller acreage in the Dutch East Indies, the remainder distributed in order of acreages in Ceylon, French Indo-China, Siam, Sarawak, British North Borneo, India, and Burma, the core of the empire coveted by the Japanese.

The concentration of all but a minor fraction of the world's supply in the Far East has always had serious implications for the United States, by far the rubber planter's best customer. Despite rapidly increasing demand for the product, the potential supply began, shortly after World War I, to exceed the demand. The economic consequences assumed

grave proportions. In an attempt to correct the situation, the British in 1922 put into effect a restriction scheme known as the "Stevenson Plan." Abandoned in 1928 because it did not include the Dutch and was not flexible enough to cope with rapid changes in a complex market, the plan nonetheless accomplished some of its purposes. One was a sharp increase in the price of rubber. An immediate result was curtailment of expansion of uses in this country and the extension of the use of reclaimed rubber. Congress investigated the situation and representations were made to the British, without avail. An unintended effect of the operation of the plan was to stimulate production in the Netherlands Indies and other non-British areas. Eventually the picture of the restrictionless Dutch waxing prosperous by virtue of self-inflicted British control and several other factors led to termination of the plan. From 1928 to 1934 production was without regulation. During this period the depression sent the price into its worst tumble (2.7 cents a pound in New York in 1932), and the British and Dutch jointly put into effect the International Rubber Regulation Agreement which controlled export and production of rubber from June 1934 until its expiration in April 1944. This scheme was more flexible than its predecessor and did cover all the major producing areas. How much it hindered normal improvement of the industry would be hard to estimate. It did keep high the price which American manufacturers had to pay, and it did restrict, through inflexibility, the amount of rubber which the United States could obtain in the critical days of 1939 and 1940.

The economic disadvantages to the American public of the tight British-Dutch control, as it has been exercised, have been great. The military loss of the far-away plantation areas to the enemy came near to being tragic. During the unprecedented demand period of World War II only the Ceylon and India plantings, comprising about one-twelfth of the Eastern total, remained as sources for the Allies.

Catastrophe was averted by the tremendous development of synthetic rubber production and the tapping of every available source of natural rubber. Attention has been redirected to the resources of the American Tropics. Large sums have been spent in stimulating the collection of wild rubber from the jungle trees, and Brazil's once great industry has, for the moment at least, been to some extent revived. The revival is a war measure, though, and little more can be expected from it. After all, the annual output of Amazonia in its heyday was only about 45,000 tons, hardly significant any more. Far more important in the ultimate is an attempt to stimulate rubber plantings in the Western Hemisphere, a wartime measure with long postwar sights. In the earlier attempts to establish plantations in this hemisphere there were a few, in Trinidad and the British and Dutch Guianas, in which Hevea was used extensively. Most of these trees failed to grow well or to yield any quantity of latex, because of heavy infections of South American leaf blight, a disease caused by a fungus, *Dothidella ulei*. The relative political instability of the governments of the period was another major factor in dampening interest in the development of Hevea plantings in several of the Central American countries where small areas were more or less experimentally planted to the tree.

In 1928 Henry Ford, following the example of Harvey Firestone in attempting to build up his own source of rubber in Liberia, began operations for the development of part of a 2,500,000-acre concession up the Rio Tapajós in Brazil

EFFECT OF SOUTH AMERICAN LEAF BLIGHT ON YOUNG TREES
Left, LEAVES OF THE RESISTANT STRAIN. *Right*, LEAVES OF A HIGHLY SUSCEPTIBLE STRAIN.

as a Hevea rubber plantation. The early difficulties of the Ford plantations were described by Bekkedahl in the article referred to above. The worst was leaf blight, the inroads of which were terrific. Whole areas were wiped out. In 1935 the Goodyear Tire & Rubber Co. started plantations in Panama and the next year extended them into Costa Rica. Goodyear had initiated a campaign a few years before to bring some rubber cultivation to the Western Hemisphere, establishing plantings in

CONIDIA OF DOTHIDELLA ULEI
SOUTH AMERICAN LEAF BLIGHT, SPREAD MAINLY BY CONIDIA, IS MOST HARMFUL IN WET SEASONS.

the Philippines as the first of the homeward steps. In Goodyear's tropical American plantations, as in Ford's, leaf blight was destructively rampant. These discouraging early ventures not only emphasized the magnitude and severity of the disease problem but also pointed a way to circumventing it by showing up certain disease-resistant stocks and demonstrating that, except for the leaf blight, Hevea lends itself to cultivation as well in the West as in the East.

When the progress of the war in Europe began to highlight the distance between Akron and Singapore, one of the foci of attention landed upon the plantation possibilities of Latin America. Consultations between the United States Departments of State and Agriculture and the governments of the tropical republics to the south revealed anxious interest on the part of many of the potential rubber-growing countries but a lack of technical knowledge as to how or where to begin.

In 1940 Congress paid heed to the shadows of the rapidly approaching crisis and the interest of our tropical neighbors by appropriating funds for a cooperative program directed toward encouragement of a rubber-producing industry in the American republics. The first step was a series of surveys of

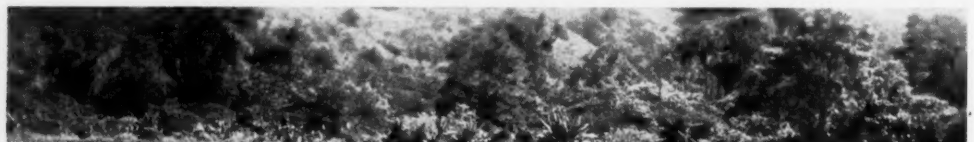
the supposedly suitable areas. Exploring parties were constituted of technicians from the United States Department of Agriculture, most of them with experience in the rubber areas of the East or on other tropical crops, and Latin American plant and soils scientists familiar with local conditions. Where within the area could plantations be developed and how far beyond the natural range of Hevea could they be taken were questions for the surveys to decide. Beyond the fundamental necessity of soil, moisture, and the other qualities of environment suited to vigorous growth of the plant were the two major considerations of the widespread South American leaf blight and the economic aspect involving, in turn, the prospects of a market at an adequate price, availability of labor, and a host of other factors.

The limiting disease, South American leaf blight, is spread throughout Amazonia and well up into Central America. In the wild its effects are relatively moderate, largely because native Hevea trees generally occur sparsely over wide areas, and between them are barriers of other nonsusceptible species. In the much denser stands of plantations and nurseries, the disease defoliates trees with amazing swiftness and disastrous effects. Thanks mostly to plant pathologists of the United States Department of Agriculture and the vitally interested Goodyear Rubber Plantations Co., new spraying methods and adaptations of older standard methods now make it possible to control the disease adequately in nurseries, mostly by the use of copper compounds. In plantations of mature trees effective spraying would be mechanically difficult and prohibitive in cost. As with most diseases the greatest hope is immunity or relatively high resistance to infection. Freedom of certain trees

RESISTANT SEEDLINGS

THESE PLANTS WERE NURSERY-GROWN FROM SEED COLLECTED IN THE ACRE TERRITORY OF BRAZIL.

from infection was observed in the early Guiana plantations. The Ford and Goodyear experiments have segregated several highly resistant strains. Most of those tested, however, are low yielding, and it is a basic premise that if new plantings of rubber are to succeed they must at least equal in yield the best Eastern ones. Superior trees are being produced by crossing Eastern strains, carefully selected over a period of many years for high yield, with disease-resistant Amazon strains. Outstanding jungle trees in Brazil, Peru, and Colombia are being studied further as possible commercial material. Planting material from such selection and breeding is amassed slowly, and successful establishment of a Latin American rubber industry depends upon immediate commercial planting to take advantage of the expanded market. To hasten production, resort is being had to an expedient used by the Ford Plantations, i.e., double budding, a procedure of which Bekkedahl has given a detailed description. Rubber planters, like many other tree growers, have made extensive use of bud-grafting superior strains onto run-of-the-wild rootstocks. The result is a uniform stand of superior trees. In 1926, a man named Cramer, in Java, interested in the possibilities of increasing yields and controlling certain local diseases, suggested improving upon nature by double budding to make a tree of three strains, root, trunk, and top, each selected for superiority under a given set of conditions. Various factors of compatibility, size relations, and developmental pattern are concerned, but several successful combinations have



DISEASE CONTROL IN A COSTA RICAN HEVEA NURSERY

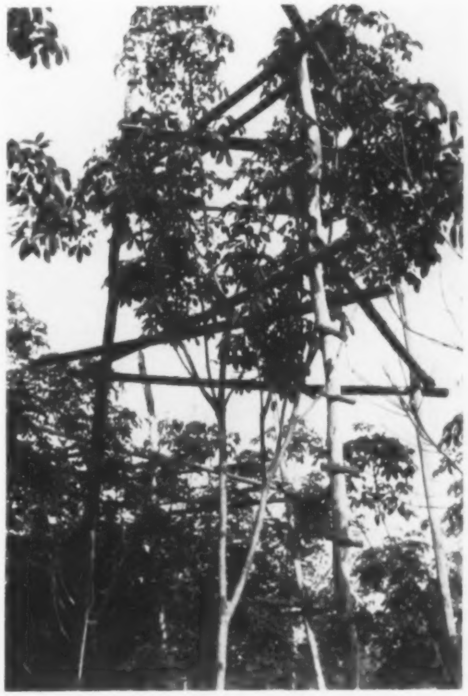
EASTERN-STRAIN SEEDLINGS ARE BEING PROTECTED AGAINST THE LEAF BLIGHT BY SPRAYING.

been made and such three-part trees are being planted in the disease areas. In practice high-yielding Eastern clones are budded on native seedling rootstocks just above the ground level. The trees are then protected by spraying until they have grown enough to permit top budding at 6 to 8 feet from the ground with a disease-resistant strain or species. Use is also being made of top budding to speed up the breeding program, for it has been discovered that buds implanted in old trees will grow, mature, and flower rapidly and profusely.

It can now be said with assurance that the disease to which the earlier tropical American Pará rubber plantations succumbed is well understood and is readily brought under control.

To fit the pattern of Latin American agriculture and take greatest advantage of the economic factors, emphasis is being placed on plantings small enough to be handled adequately by a single farmer or single family. More than half the Eastern rubber is supplied by such enterprises. Such plantings obviate the necessity for large movements and organizations of labor, and require relatively little capital. Further, they provide urgently needed diversification, and most of the areas where Hevea can be grown have been cursed by all the hazards of one-crop farming, mainly too much coffee or bananas.

The wartime implications of this encouragement of Hevea planting in the West were many. It represented assurance of expanding the supply of natural rubber if the period necessary to retake the Eastern areas had been prolonged beyond the time the first plantings mature. It has given the governments and peoples of tropical America a sense of direct participation in both the war effort and the basic planning for postwar economy, along with an appreciation of earnest effort on our part to assist them to an active place in the world.



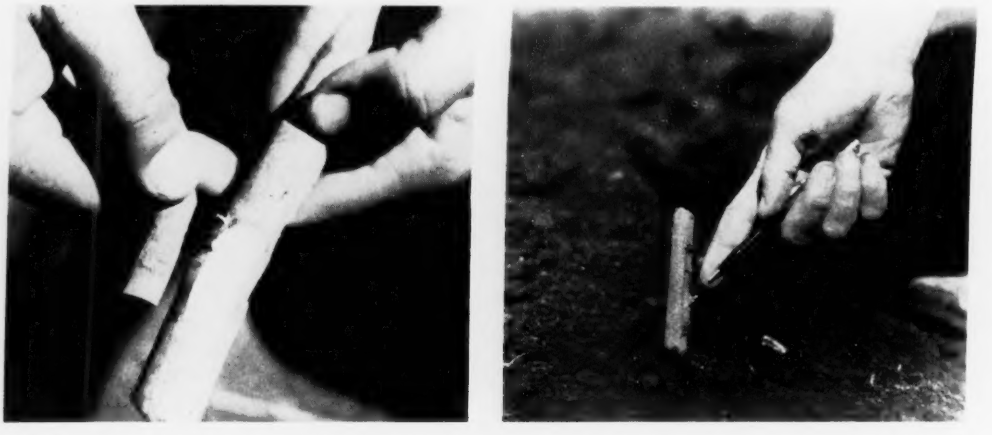
HYBRIDIZATION

BLIGHT-RESISTANT TREE BEING USED IN CROSSING TO COMBINE RESISTANCE WITH HIGH YIELD.

The war did much to speed up industrialization of Latin America. The postwar years undoubtedly will see more highway building, partly as a result of continued industrial and agricultural expansion in attempts to raise living standards and partly as a bid for American tourists. The total effect of this and other developments will be a sharp rise in domestic rubber requirements which, in many countries, were already becoming higher before the war. Yet any increase would take only a small proportion of the potential producing capacity. In Mexico, for instance, 25,000 acres of selected Hevea would furnish four times the 1941 imports. A rubber supply within the borders of the smaller nations is insurance of obtainability of this increasingly vital material.

For various reasons rural population shifts are important in the current

development of many of the tropical American countries. In Mexico the *ejidal* system of communal farming is part of an agrarian reform which is a pillar of the present government. In Guatemala overproduction of coffee and consequent decline of the market have stranded a large agricultural population. In Honduras, Nicaragua, and Costa Rica the inroads of the Panama and Sigatoka diseases have cut banana production very sharply and left groups of small farmers without a cash crop. Colombia is undertaking an immense colonization scheme in its rich tropical northwest territory. Brazil moved about 26,000 rubber workers and their families into the Amazon Valley to bring out wild rubber during the war, and several other countries have population problems in areas admirably suited to Hevea. Rubber represents one of the most hopeful solutions for the problems of these stranded populations and colonizing operations. Planted over small acreages with subsistence food crops, it will provide cash income to the individual farmers or government-settled colonists. Rubber produced in this manner is less subject to labor cost factors, since its selling price tends to be measured in terms of the urgency of the cash requirements of the grower rather than against national labor wage rates.



BUDDING INSURES SUPERIOR TREES
Left, REMOVING A BUDDING-PATCH FROM STICK OF HIGH-YIELDING HEVEA BUDWOOD. *Right*, SELECTED BUD STARTS TO GROW AFTER INSERTION. SEVERAL KINDS OF BUDDING ARE DONE.

The question of production costs is, of course, a controlling one. Experience to date indicates that Latin American rubber produced in either small or large plantings can compete successfully in the market at or even considerably below the prewar level of 16 to 22 cents a pound. Any Latin American disadvantage in labor costs may be compensated for by increased yields and reduced shipping charges. Replacement of the already established Eastern plantings with higher yielding selected clones is a task that will take decades to complete. As it progresses, however, high-cost marginal producers will be eliminated.

So far, synthetic rubber has not been produced at prices which would permit it to compete, unaided by some subsidization, with natural rubber. That the almost miraculous development of the synthetic industry saved the war effort is obvious, as is also the fact that a large synthetic industry is here to stay—this last because in many uses synthetics are superior to natural rubber and are a military precaution and a safeguard

against unfavorable price manipulations by the Eastern rubber interests.

Synthetic alone, however, is not enough. Wartime experience has indicated the manifest superiority of natural rubber over any of the synthetic substitutes as far as the manufacture of certain products is concerned. Further, the development of natural rubbers with particular outstanding qualities by selection or treatment is a field which as yet has hardly been touched. The rubber market will definitely depend in the future upon both natural and synthetic. It is estimated that for some years after the war consumption can absorb at least 1,500,000 tons of rubber, natural and synthetic combined. No estimate can be made at the present of the balance which will be struck eventually between natural and synthetic. But no one doubts that, regardless of what the balance is, large stocks of natural rubber will have to be available at all times. Dependable supplies of Latin American rubber have two extremely important advantages for the United States. As a noncompetitive crop sold to us rubber will build up dollar exchange, and Latin American purchases are an important part of our foreign trade. Further, tropical American plantings will provide a strategically located and readily accessible supply available in an emergency without the heavy cost attendant to storing a minimum supply.

LATIN AMERICAN RUBBER
SHEETS HANGING IN THE SMOKEHOUSE OF THE GOODYEAR SPEEDWAY ESTATE IN COSTA RICA.

As an example of international collaboration, this attempt to bring some of the Hevea rubber industry home is a hopeful example. Initiated by mutual interest and developed by the Latin American countries themselves at their own expense, with scientific and technical assistance and advice from the United States, toward a mutually advantageous goal, the program is assisting materially in cementing good neighborliness and building toward hemispheric solidarity.

RESEARCH ON PHENOTHIAZINE AS AN ANTHELMINTIC

By PAUL D. HARWOOD

SOME insist that practical or economic considerations are so much smoke in the eyes of the scientist, vastly limiting his chances of increasing human knowledge, while others claim that any research having no practical end in view is evidence of so much wasted energy. The history of the research on phenothiazine as an anthelmintic, or worm killer, is perhaps illustrative since our studies have been confined largely by an economic smoke-screen. I wish to call attention to some of the characteristics of this smoke-screen, to mention some of the problems successfully solved behind its somewhat restrictive protection, and to indicate other problems where exploration was barred because the search led into the hazy obscurity of theory.

There is little doubt that, thus far, dollars and cents have limited the study of phenothiazine as an anthelmintic. The estimate of the United States Department of Agriculture that the drug has saved annually more than ten million dollars in meats, hides, wool, and surgical catgut suggests appreciable progress within these limits. Furthermore, estimates place the return to the sheep industry of Kentucky alone at three million dollars in a single year. These estimates, which by their impressiveness tend to cover the gaps in our knowledge, are obviously discrepant, since phenothiazine is useful in treating horses, cattle, goats, swine, and poultry, as well as sheep. The Department of Agriculture may assert privately that ten millions represents only one-half the "guesstimated" annual savings; the other half is charged to Federal caution against possible overenthusiasm. Perhaps the total savings are nearer to the more sumptuous figure that may be inferred from the Kentucky estimate since it is supported by observations made on Kentucky farms by Prof. R. C. Miller, sheep specialist. Possibly even the higher figure is meiotic.

We can be more certain of the effect of this anthelmintic research on the chemical industry. Phenothiazine was only a laboratory compound when the Federal zoologists started to kill worms with it in 1938. By 1943, three million pounds were manufactured and sold to farmers for an average price of one dollar per pound. Farmers as a group are pretty fair businessmen. They did not spend three million dollars on phenothiazine and many hours administering the drug to their livestock without objective evidence of dollars returned. How many dollars? I haven't the slightest idea.

A dollars-and-cents estimate of values may be misleading in a time of war and of the OPA. Just when military surgeons began sending out frantic SOS's because of the impending shortages of surgical catgut, phenothiazine became available. Surgical catgut is made from the guts of sheep. The knotty lesions produced by nodular worms regularly made the intestines of many American sheep unsuitable for the manufacture of catgut (Fig. 1). In a single season phenothiazine conquered the nodular-worm disease of sheep over wide areas. A money value is placed on the surgical sutures thus saved, but in wartime and in face of threatened shortage does this represent the true value?

These practical achievements were not obtained without error and dispute, although they appear inevitable to one

looking backward. The experimental therapy of verminous infections demands considerable knowledge in chemistry, physics, and statistics, as well as in zoology and veterinary medicine. Few of us possessed all the training desirable, and occasionally we were impatient with one another's shortcomings. Therefore, we made our share of errors; we sometimes debated trivial issues acrimoniously; but all of us, I think, were sometimes a little wistful because a particularly inviting field could not be explored. Looking backward, we can be more tolerant and, perhaps, profit a little by our errors and by calling to mind again a few of those accessory problems to which little or no study has been given, thus far, because they were not immediately productive of practical results.

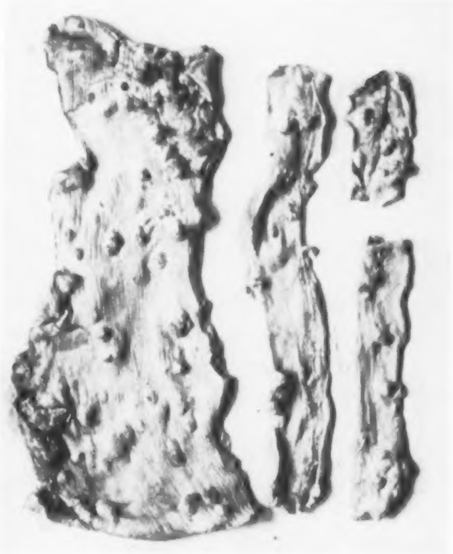


FIG. 1. FRAGMENTS OF SHEEPGUT SHOWING SEVERE LESIONS CAUSED BY NODULAR WORMS PICKED UP BY THE ANIMALS ON PASTURE.

Phenothiazine was used first as an anthelmintic in the Zoological Division of the U. S. Bureau of Animal Industry. This Division had already accumulated an impressive series of significant first discoveries. Here Theobald Smith discovered the import of the transmission of infectious diseases by arthropods, and here C. W. Stiles slighted his work with domestic animals to establish the presence and character of hookworm disease in the United States. Here a young zoologist, Maurice C. Hall, started to evaluate all known vermicides only a few years after Ehrlich discovered arsphenamine. This project, which has been pursued continuously to the present time, resulted in the discovery of the hookworm remedies, carbon tetrachloride and tetrachlorethylene, that are used in human medicine today. These discoveries attracted widest interest because they applied either directly or indirectly to human welfare. Beside them may be placed an enormously greater number of investigations affecting the parasites of both domestic and wild animals.

The treatment project was deserted in 1936 by Hall and those of his staff who were experienced in chemotherapeutic research because their achievements won for them greater opportunity for service in the National Institute of Health. Although relatively inexperienced, I was, of necessity, placed in the key position on the project. At first I hoped to find in the record of past experiments some guiding principles such as chemists use to estimate the characteristics of unknown compounds. Caius and Mhaskar (inevitably nicknamed Chaos and Massacre), Fischel and Schlossberger, as well as the records of the Zoological Division were studied without finding any trustworthy guide. Yet two publications, only a month apart in time but half a world apart in space, were fascinating, for Hall as well as Caius and Mhaskar had pointed out that chloroform was effective against hookworms but dangerously toxic. Simultaneously they reasoned that carbon tetrachloride might be more effective and less toxic because each molecule of the latter drug

was saturated with chlorine. The hypothesis seemed valid when Hall proved carbon tetrachloride superior to all known drugs for removing hookworms from dogs, but it was destroyed completely when he and his colleagues made further studies on the halogenated hydrocarbons.

Other false hypotheses which, nevertheless, led directly to very practical results are recorded in the literature. The diamidines, which are now used against certain types of parasitic diseases, developed from such a false start. Why not, therefore, select compounds largely at random and test them critically after Hall's established method? It was an exciting question, for who could tell what common chemical might prove to be the solution to existing problems such as controlling the nodular-worm disease of sheep (Figs. 2, 3, 4), which older and more experienced men had pronounced unsolvable? Perhaps the traditional attempts to associate chemotherapeutic activity and chemical structure were foredoomed to failure—even as the search for the philosopher's stone. But as that earlier search had produced modern chemistry, so the confident, though false, theorizing of the biologists had led to valuable results.

Each annual report of the Chief of the Bureau of Entomology and Plant Quarantine exhibited in the late 1930's definite enthusiasm over a new insecticide called phenothiazine. I did not locate a supply of this new insecticide because I was not familiar with the synonym, thiodiphenylamine, under which it was listed in the catalogues. However, in January of 1938 E. F. Knipling's manuscript describing the action of phenothiazine against horn-fly larvae in cattle feces was referred to the Zoological Division. Immediately Knipling's superior, Dr. F. C. Bishopp, was asked for the source of phenothiazine, and in a few days the Zoological Division received from him a sample of the chemical. It was tried first against two important parasites, the broad-headed tapeworm in poultry and the protozoan of cecal coccidiosis in chickens. In both tests, phenothiazine failed to show any promise of curative action. Even today it has no proved action in any protozoan or cestode infection.

In May 1938 we received a gift of some worm-stunted pigs. At this time starvation of the host was considered essential to success in anthelmintic medication. Perversely, we gave phenothiazine to one of the pigs in a mixture of feed. Twenty-four hours later this pig, as well as another animal treated

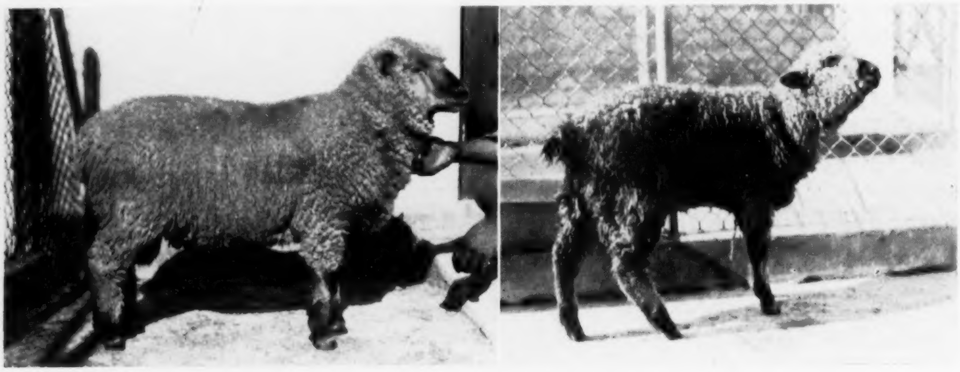


FIG. 2. EXTERNAL EFFECTS OF NODULAR-WORM DISEASE ON SHEEP

GRADE RAM AT LEFT WAS RAISED NEARLY WORM-FREE. GRADE RAM AT RIGHT WAS INFECTED EXPERIMENTALLY WITH NODULAR WORMS. (PHOTO BY SARLES, U.S.D.A. TECH. BULL. 875.)

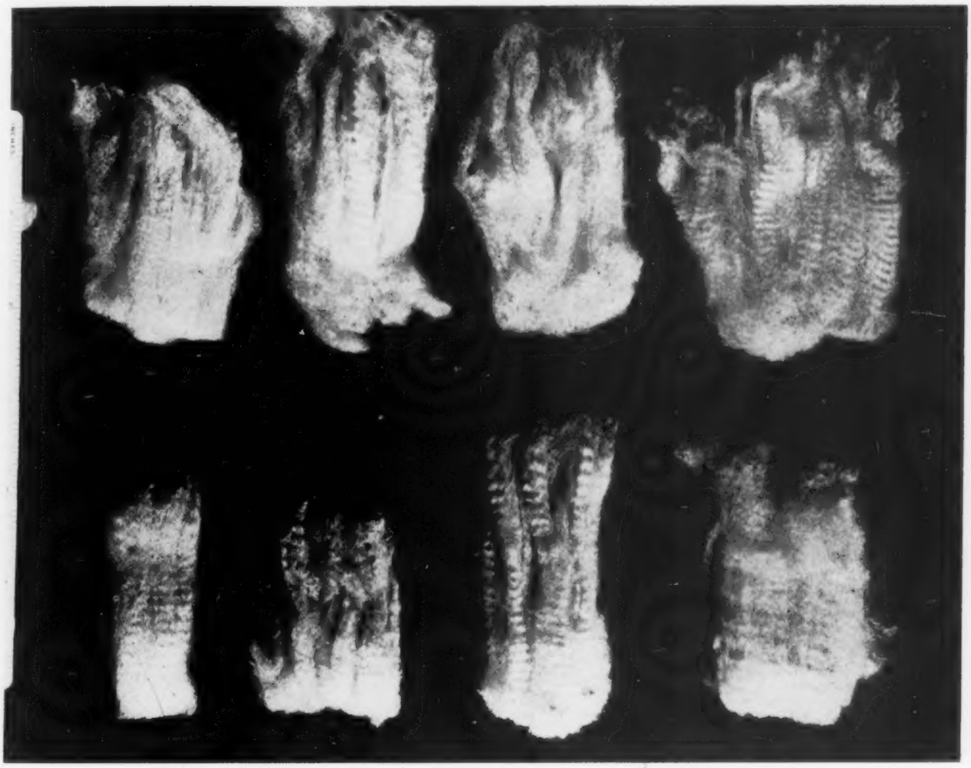


FIG. 3. EFFECT OF NODULAR-WORM DISEASE ON WOOL
Upper: FROM 4 UNINFECTED SHEEP. *Lower:* FROM 4 HEAVILY INFECTED ANIMALS. (SARLES.)

after the traditional manner, began to eliminate the untouchable nodular worms in large numbers. This was only the first tradition of anthelmintic medication to be reversed by the new drug. In September of that year we undertook the real problem, the application of the new drug to the control of the nodular worm of sheep. The greater part of the routine work fell upon a veterinarian who was brand-new to research with worms and vermicides. Although lesions of previous infection were numerous and extensive, the first animal, to his profound distrust, harbored only one nodular worm, which the drug removed. He was assured that the circumstance was ordinary, but he was not convinced. He feared the trivial results were due somehow to his failure through inexperience.

A young animal in poor condition was selected next as a likely subject. The veterinarian was advised to wait until Monday before treating the animal, but he dosed it immediately, although it was late Thursday afternoon. Friday was uneventful, but by Saturday morning there were hundreds of worms to be collected, hunted out, and counted. In the Federal laboratories at Beltsville, Md., no one was expected to work outside of official hours. Consequently, the veterinarian, who was proceeding cautiously, found himself locked away from his work just as it became interesting and exciting. It was a beautiful Indian summer afternoon when he called me from the garden and asked for assistance in getting back to his work. Apparently almost everyone in the division was on

some outing. After much telephoning we located a key and succeeded in completing the test. In a single dose phenothiazine had removed 296 nodular worms and 125 hookworms from a sheep, as well as uncounted tens of thousands of tiny bankrupt worms. The technique of Hall's critical test which was used in these experiments is so deceptively simple that the novice almost always expects to accomplish too much in too short a time. Hall delighted to recount his own

FIG. 4. EFFECT OF NODULAR-WORM INFECTION ON MEAT PRODUCTION

TWELFTH-RIB CHOPS FROM 8 LAMBS—CHOPS FROM EWES AT LEFT, FROM RAMS AT RIGHT. THE INDIVIDUAL LAMBS OF EACH PAIR (FROM TOP TO BOTTOM) WERE GIVEN EXPERIMENTALLY 0, 280, 2,800, AND 28,000 LARVAE OF THE NODULAR WORM, RESPECTIVELY. (FROM SARLES.)

early experience with the test to novices in the Zoological Divison.

"I dosed six horses for bots at one time," he would remark, then smiling cryptically he would puff at his pipe.

Invariably the novice would ask, "Was that too many?"

"Too damn many," Hall swore casually and without emphasis, "within two days I was completely hidden behind garbage cans of manure, and still it kept coming. One horse would have been too many."

Warned by Hall's story, I was conservative when it came time to test phenothiazine in horses. To Dr. Schwartz's request for an estimate of the number of animals needed, I replied, "One at a time will be sufficient." Dr. Schwartz smiled tolerantly but as usual continued his careful planning.

The results of our first tests were released quickly in a technical journal. Consequently, interested investigators were able to determine in a relatively short time that phenothiazine, which is valueless against certain parasitic worms, was, nevertheless, more effective against a greater variety of verminous vermin than any other anthelmintic known heretofore. Its effectiveness in parasitic conditions of various ruminants, of horses, of swine, and of poultry was proved in repeated tests from all parts of the world. Fortunately, we had access to De Eds's invaluable and extensive studies, which were undertaken originally at the instigation of the U. S. Bureau of Entomology and Plant Quarantine, on the toxicity of the compound for laboratory animals. This background furnished justification for proceeding to practical application with rather limited toxicity tests on each species of animal. For the most part it was adequate, but unfortunately a few horses proved extremely sensitive to the drug. Recent research in California and in the Beltsville Research Center hold promise of overcoming this handicap to the use of phenothiazine for the control of equine parasites.

Although Hall's synthesis of chemistry and chemotherapy failed, he bequeathed his critical method of proving vermicidal materials to those who followed. In this method all worms removed by a treatment are collected and counted. The treated animal is killed as soon as elimination of helminths ceases, and any worms which survive the treatment are likewise collected and counted. Thus precise information is obtained. The phenothiazine data collected after this method in the laboratories of the Zoological Division, at the Beltsville Research Center, were quickly corroborated at other institutions where other techniques were often used. Yet conclusions based on these experiments were severely criticized because statistical analysis cannot be applied to data of this type. In due time an extensive coordinated trial, involving the services of over a dozen scientists, convinced the statisticians and proved by further corroboration, if such were necessary, that conclusions based upon Hall's critical method, which has been used effectively for three decades, are still reliable.

Nevertheless, statistical methods have invaded the field of anthelmintic research quite successfully from another direction. Animal husbandmen do not always appreciate the necessity of determining precisely those helminths that are affected by a particular drug, nor are they able to estimate the value of the data collected by means of the critical test, for to most of them a species of worm is only an awkward name. The only important question, as these scientists conceive the problem, is the effect of treatment on the health of the animals, particularly on the rates of gain in young animals. Furthermore, some nutritionists felt that parasitic disease was merely an expression of malnutri-

tion, a state supposedly unknown to parasitologists. However, the British investigators Stewart and Crofton, with the aid of Prof. R. A. Fisher, demonstrated that parasitism and malnutrition are distinct. In Great Britain many sheep were unthrifty—the condition being known as pining. The cause of pining was variously described as parasitism or as a nutritional disturbance due to a shortage of certain minerals in the diet. Stewart and Crofton divided a flock of sheep on a pasture where pining was suspected into four groups: a control group, a group receiving phenothiazine, a group receiving a drench containing several minerals that were supposedly present in insufficient amounts on the pasture in question, and a group receiving both drug and minerals. All sheep were weighed at intervals. The differences in uncorrected mean gains, which favored the treatments, were as follows:

Phenothiazine versus controls	4.7 pounds
Minerals versus controls	4.2 pounds
Phenothiazine and minerals versus controls	8.9 pounds

The raw data, therefore, suggest that the sheep suffered both from a mineral deficiency and from parasitism, but the range of the gains made by individual sheep was, as usual, much greater than the mean differences. Therefore, interpretation was difficult or impossible without statistical analysis, which was supplied by Prof. Fisher. After appropriate analysis he was able to state, "It will be seen that there is practically an additive effect of phenothiazine and of minerals and no appreciable interaction. These two main effects are unquestionably significant."

Heretofore parasitologists have been quite willing to concede that some interaction occurred between malnutrition and parasitism to the detriment of the host. Now Stewart and Crofton's results suggest that the minority, i.e., the parasitologists, should take a more independent view of their science. For ammunition with which to implement their war of independence these scientists must acknowledge the usefulness of statistical methods which, undoubtedly, have won a permanent place in helminthic research, but these methods must remain secondary to the facts-of-life pertaining to parasites.

The mechanism by which phenothiazine destroys the helminth remains unknown. In this connection, the extreme insolubility of the drug attracted attention at once. Hall and his colleagues had discovered that superior anthelmintic efficacy among the halogenated hydrocarbons was associated with the degree of water solubility rather than with the amount or type of halogen present in the molecule. Most other types of vermicides had similar properties as regards water solubility. At saturation from 1 to 10,000 parts of water of room temperature are necessary to dissolve 1 part of the previously known, effective anthelmintics. However, 800,000 parts of water are required to dissolve 1 part of phenothiazine. Although phenothiazine is extremely insoluble, it is known to form within the animal body certain compounds by oxidation.

Usually the leuco-forms are excreted in the urine of the dosed animals. Therefore, I reasoned in an early paper that phenothiazine as such may not be the actual anthelmintic but that some more soluble compound derived from the drug may be the vermicidal agent. The investigation of the hypothesis was beyond my resources at the time, but competent investigators soon tried available oxidized derivatives, including phenothiazone and thionol, only to prove them worthless. Nevertheless, J. M. Zukel found that phenothiazone as well as phenothiazine was an active insecticide against the American cockroach. He reported that the lethal compound

for cockroaches was conjugated leucothionol, which was produced in the body of the insect from either phenothiazine or phenothiazone but not from thionol. Experimental study of this problem might yield interesting data for the anthelminticist.

Possibly most investigators have dreamed of leisure to learn other techniques, to apply them to new experimental designs, and actually to conduct the experiments which might explain this puzzle. Since the practical value of the results remains questionable, most of us, whose livelihood depends upon the results of our research, have of necessity directed our attention toward practical problems which are far from completely explored. However, a few youthful investigators, confident of their new research ability, have been scornful of our yielding to the dollar-pressure. They have promised publicly to raise phenothiazine medication above the "merely empirical" and to elucidate the mechanism of phenothiazine activity, although analogous mechanisms remain unknown for all other anthelmintics except the escharotic phenols. Nothing has come from these lofty promises. Meanwhile, the Canadian H. B. Collier is calmly and quietly reporting his explorations which closely border and may some day enter this interesting field.

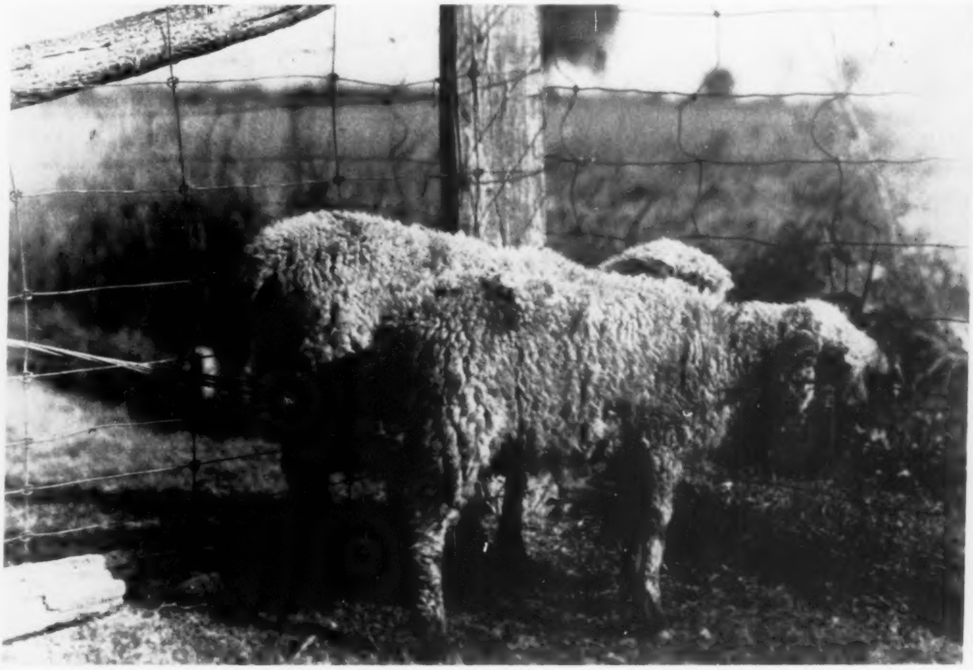


Photo by Bell, Ohio Agr. Exp. Sta.

FIG. 5. LAMBS SUFFERING FROM WORMS

THESE SHEEP ACQUIRED A MIXED INFECTION ON OHIO PASTURES. LOSS FROM WORM DISEASES EVERY YEAR IN A SINGLE OHIO COUNTY FORMERLY WAS EQUIVALENT TO A TRAINLOAD OF LAMBS.

To helminthologists phenothiazine has broken precedents and principles within its field as consistently as did the late Mr. Roosevelt within the political arena. Fortunately, the scientists have accepted the former innovations with better grace than some of us Republicans were able to accept the latter. Since its earliest days, the Department of Agriculture had discouraged self-medication

of animals with drugs mixed with salt. Sulfur, tobacco, copper, and various mineral mixtures were not only useless when given in salt, the substances sometimes proved decidedly toxic. On the other hand, livestockmen preferred the easy way; namely, self-medication. Since Knipling was able to poison hornfly larvae in cattle manure by feeding to the animals very small amounts of phenothiazine, the possibility of controlling worms by poisoning the free-living stages which develop in the manure was apparent to all informed helminthologists. We received letters on the problem from as far away as Australia, we discussed it frequently at Beltsville under the leadership of our chief, Dr. Benjamin Schwartz, and we worried over the possible undesirable effects, such as wool-stains, that might result from continuous administration. Obviously, the problem required cautious preliminary study such as it received from Shorb and Habermann. Once these investigators had determined the phenothiazine-salt concentrations acceptable to sheep and deadly to worms, numerous cooperators appeared. Within two years the Department gladly reversed a time-honored policy and recommended self-medication of sheep as a means of parasite control.

For the first time an anthelmintic has been used in a manner analogous to the use of insecticides in *Anopheles* control where the main objective is the conquest of human malaria. The cecal worm of domestic poultry carries in its egg the protozoan that causes blackhead disease in gallinaceous birds, particularly turkeys. Scientists from the Washington State Experiment Station demonstrated that phenothiazine is very effective for the removal of cecal worms from chickens. Overleaping the next logical step, namely, determining the efficacy of the drug against the cecal worm in turkeys, we applied our new knowledge directly to the control of blackhead by treating large numbers of these birds with phenothiazine. Apparently we have thereby discovered a means of controlling a serious disease by destroying its carrier; but had we chosen pheasants instead of turkeys we might have been disappointed, for limited tests carried out in Ashland, Ohio, suggest that the drug may be of relatively little value for removing cecal worms from pheasants. Usually in anthelmintic medication the size of the dose is regulated by the size of the animal, the larger animal receiving the bigger dose. Nevertheless, records of several hundred tests which are being prepared for publication suggest that an effective dose for large fowls may be less effective with small fowls. Possibly the failure of phenothiazine in pheasants is associated with the small size of the host, but the problem requires further study which we cannot give to it in Ashland at present.

Parasitologists have long known that the most serious losses from parasitism frequently are unapparent. When malaria is controlled within an endemic area, other chronic conditions may be greatly alleviated. Also they know that cattle are extensively infected with gastrointestinal parasites, but they are able to prove only comparatively light losses in these animals. They hesitate to claim for these hosts the existence of the unapparent but serious losses known to follow extensive infection with many types of parasites in other hosts. Phenothiazine quickly proved valuable against the obvious cases of severe gastroenteritis in bovines because of its specific effect on a variety of nematodes associated with this condition. Lately evidence of extensive, but unapparent, losses in the cattle industry is beginning to accumulate because of investigations of phenothiazine. The Survey Committee of the National Veterinary Medical Association (of Great Britain) reported in

February 1945: "Some veterinary practitioners maintain that sub-clinical parasitism in adult cattle is widespread. They report a rise in the milk yield and a noticeable improvement in the condition of adult animals in apparently normal health following the administration of phenothiazine."

Moreover, we have recently published the results of experiments conducted in Ashland County on steers that harbored relatively few parasites. Animals from a single herd were divided and placed on similar lots. A mixture of phenothiazine and salt was given to one group, while salt alone was given to the other. Although there was never any evidence of clinical parasitism in either group, the steers receiving medicated salt outgained the steers on salt alone in two experiments conducted in successive years. The differences were statistically significant. Such observations suggest that the drug may find wide application in the cattle industry, but many more studies are needed.

There is little need to mention other practical consequences of phenothiazine research. The problems it has solved are already cut and dried, while others are being carved. The highway to these goals has offered for exploration many a tempting byway, but pushed as we were by dollar-demands we never had a chance to turn aside; to study, for example, the method by which phenothiazine kills worms. We have neglected fundamental problems, some have said, but it is impossible to define fundamental as it applies to science. To some "fundamental" means the study of smaller and ever smaller particles such as molecules, atoms, and electrons. Yet is a proton essentially more fundamental than a living being? Indeed, "fundamental research" is no more susceptible to an accurate definition than "practical research." Not many years ago, I witnessed the discomfiture of a Government bureau which had been charged with the duty of controlling an important insect pest of livestock. Dutifully the bureau spent large sums annually "controlling" the pest. One year they discovered there were two distinct but closely related species of insects involved—one essentially harmless, the other very troublesome. Unfortunately, many of the control measures recommended had been aimed directly at the relatively harmless form. A little preliminary work by an "impractical" taxonomist might have saved many millions of dollars and much valuable research time. In truth, the unknown remains unknown both in fact and in significance until some bit of it is objectively studied. Any attempt to classify it as practical or ideal, as fundamental or superficial, as god or devil will prove, in specific cases, erroneous, for the classification of the unknown must be based largely upon reasoning by analogy from established premises.

Yet we may not censure a bureau that has consistently requested larger appropriations for taxonomic research because too small a portion of its funds were allocated by Congress to the investigation of insect identification. Only the initiated can foretell with reasonable accuracy the points which are likely to yield fundamental or significant results. Until scientists have broader control of their projects, we may expect very frequent repetitions of this embarrassment. Even planning by the initiated can only reduce, not wholly obviate, such errors. Opportunity for several investigators to attack a problem independently, according to their separate concepts of what is fundamental, seems most likely to keep research close to the optimum of productivity. Even a relatively minor subject, such as phenothiazine as an anthelmintic, has required thus far the services of more than a hundred scientists to reach its present, imperfect state of development.

Others will contribute before our knowledge is complete. No one man, or group, could have accomplished all this by working in seclusion. Through cooperation we may hope for a practical investment of the problems remaining in this field.

Many of the practical investigators of phenothiazine were trained in such academic pursuits as systematic zoology—"butterfly chasing" it is called by some deprecators. Therefore, some helminthologists are not unfamiliar with abstruse science. Indeed, in the Zoological Division, we sometimes discussed in the midst of blue tobacco smoke such fundamental problems as the role of helminths in the transmission of diseases. Possibly, we reasoned, some human disease for which no clear etiology is known (for example, poliomyelitis) is carried by a helminth. The Division was not able to undertake the problem because of obvious limitations of equipment and authority. However, it never permitted its limitations to grow into frustrations. Similarly, the students of phenothiazine have not scorned to consider either the practical or the recondite. Slowly, they hope, the more esoteric, rather than fundamental, considerations which have been slighted may be filled in. For the present, however, the practical research which also leads to worth-while results is the only type that can be justified to such employers as the U. S. Congress.

COMMUNION AT MIDNIGHT

The hour is late; I put my books aside.
The empty sheet before me mocks the hope
I had when I began. Oh how we grope
From clue to clue before the one is tried
That brings success. I sigh, and quit the room,
Meaning to leave my work behind, but no . . .
And burdened with unbidden thoughts I go,
Head bent, and gloomy, to the outer gloom.

The campus clock strikes with a somber tone.
I pause, and turn, and raising up my head
I see the darkness marked by squares of light
Where other men still labor in the night;
Dejection passes, and there comes instead
The warming thought that I am not alone.

CLARENCE R. WYLIE, JR.

EARLY MAN IN OREGON

STRATIGRAPHIC EVIDENCE*

By L. S. CRESSMAN
DEPARTMENT OF ANTHROPOLOGY, UNIVERSITY OF OREGON

WHEN did man, that is the Paleo-Indian, first come into Oregon? This, of course, is but one aspect of the larger question: When did man enter the New World? Obviously his arrival in Oregon must have been somewhat subsequent to his setting foot on the Western Hemisphere. His cultural remains have been found in the High Plains east of the Rocky Mountains from Saskatchewan to Mexico, with some scattered evidence of uncertain significance in the lower Yukon of Alaska. He has been reported from Florida, and in recent years impressive series of archeological finds have been made in the Great Basin, lying between the Rocky and Cascade Mountains.

* This article and the two following ones by Drs. Hansen and Allison were based on papers presented at a symposium on Early Man in Oregon at the annual meeting of the Oregon Academy of Science, Portland Ore., January 13, 1945. They are here published together as an example of an effective integration of archeological, botanical, and geological knowledge in a common research problem.—EDITOR.

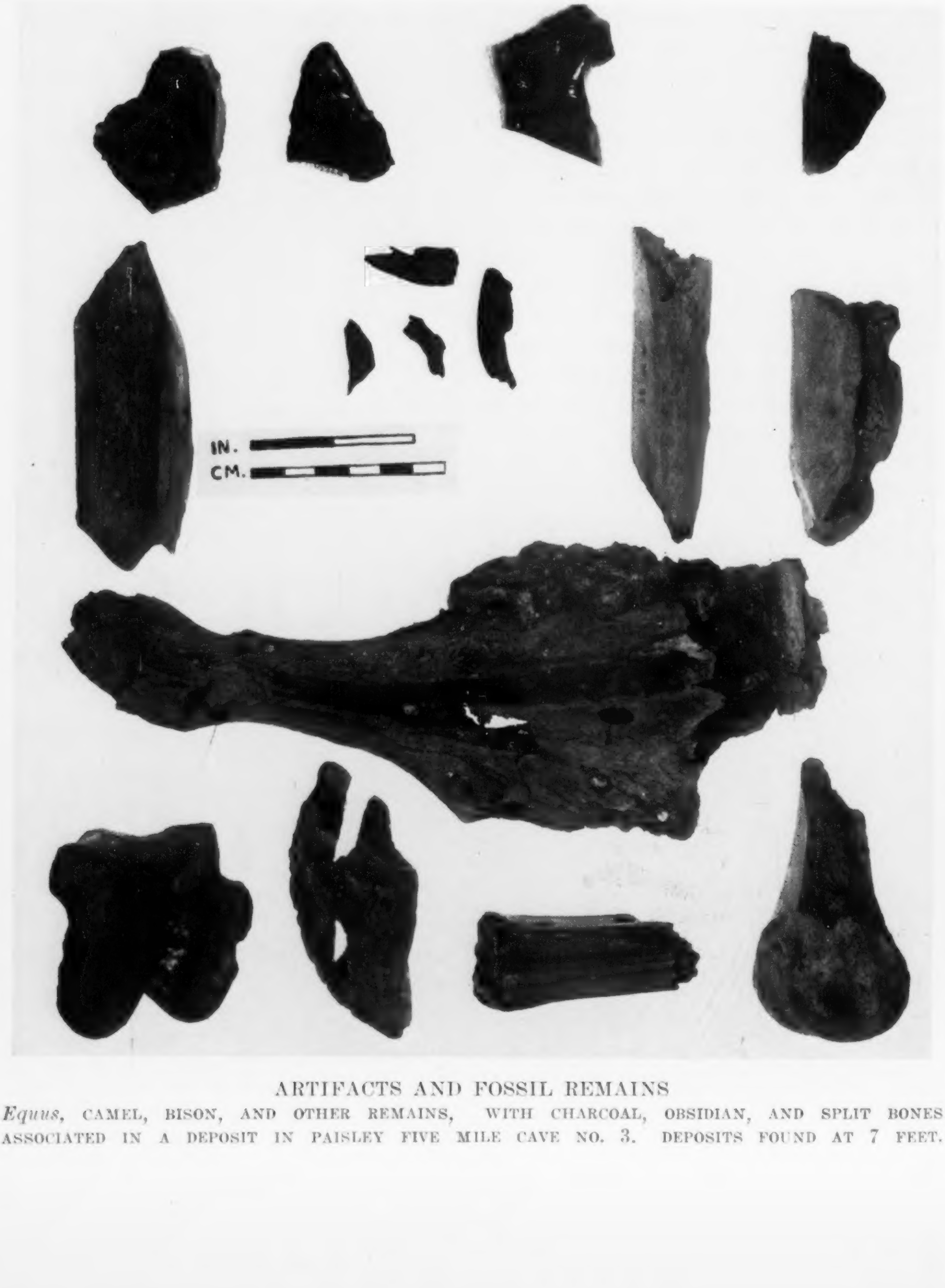
In many of these instances human remains have been associated with those of an extinct fauna characteristic of the Pleistocene—*Equus*, camel, *Bison taylori*, sloth, dire wolf, mammoth, and others. What does this association with an extinct fauna mean? It obviously indicates that we can correlate the time of man's occupation of this vast area with that of this Pleistocene fauna and that therefore we are dealing with Pleistocene man. Or the association may simply be evidence that the Pleistocene fauna actually did not become extinct until Post-glacial times. The significance of the association depends upon the time of the extinction of Pleistocene fauna, an event varying probably both in time and space.

Remains of Early Man have been found, too, in situations indicating that the climatic conditions prevailing in his time were different from those of the present. We find him associated with beds of old lakes, such as those in eastern Oregon, Lake Mohave in California, and

TEST PIT AT LOWER KLAMATH LAKE, 1940. MOUNT SHASTA IN BACKGROUND

others, all of which are now dry and possess only limited power to support life under primitive conditions with its great dependence upon the natural environment. We also find him associated with such geological phenomena as volcanism. This is best illustrated in Oregon by sites in Summer Lake and Fort Rock Valley, where we find the archeological remains separated by beds of pumice—in Summer Lake from the explosion which formed the crater in which Crater Lake now lies, and in Fort Rock Valley from the Newberry Crater some 20 miles to the north.

At this point we should define our



ARTIFACTS AND FOSSIL REMAINS

Equus, CAMEL, BISON, AND OTHER REMAINS, WITH CHARCOAL, OBSIDIAN, AND SPLIT BONES ASSOCIATED IN A DEPOSIT IN PAISLEY FIVE MILE CAVE NO. 3. DEPOSITS FOUND AT 7 FEET.

terms for a common basis of understanding. By Early Man we mean the representative of *Homo sapiens* sometimes called the Paleo-Indian. He is not, as some have wished to think, a specimen suggestive of the pre-*sapiens* type like Neanderthal man, but a true representative of *Homo sapiens*. We shall use the words Pluvial and Postpluvial throughout this paper. Pluvial period will refer to the period contemporaneous with, and slightly subsequent to, the last glaciation and characterized by a greater precipitation and somewhat lower conditions of temperature than at present. The area affected by the Pluvial period extends from the northern Great Basin of south-central Oregon roughly to the Mexican border and trans-Pecos in Texas. This area was once characterized, as O. E. Meinzer has shown, by a vast system of lakes without outlet dependent for their water supply primarily upon precipitation and its loss through evaporation. It is now characterized for the most part by dry lake beds, but in some places there are small bodies of water that last throughout the year, while in others there are only playas limited to a few weeks, more or less, at the time of the spring runoff. By Postpluvial we refer

NEAR THE NARROWS
LOOKING SOUTHWEST OVER LOWER KLAMATH LAKE.

KNIVES FROM WIKIUP DAM SITE NO. 1
FOUND WELL UNDER BED OF MT. MAZAMA PUMICE.

to the period following the retreat of the ice and the corresponding northward movement of the storm tracks, with reduced precipitation and rising temperature. Postpluvial corresponds in the main to the expression Postglacial or Postpleistocene. Since this term is well established in the literature, and the chronology has been worked out in terms of the divisions of the Postpluvial, we shall use it in our discussion.

Archeology has for its purpose the reconstruction of human history previous to the time of written records or the memory of man. Its first function is to orient its findings in space and time. The space problem is not difficult, but the time problem often proves to be a troublesome hurdle. This time problem is of two kinds. There is the simple matter of establishing relative times for the specimens dug up, that is, which is earlier than another, and this is the familiar problem of stratification with which the geologist works. It has some of the same difficulties of confusion of beds or layers that the geologist faces.

The second problem is that of establishing an exact or reasonably exact chronology. This means that some reference point, the age of which is known, must be established, and the archeologist then may orient his finds in time with reference to this datum.

The archeologist, in order to work out his chronological record, must combine his knowledge with that of the cooperating geologist, paleontologist, botanist, climatologist, and sometimes other specialists such as the bacteriologist and the pathologist. He is not always able to find a primary reference point in any one of the fields dealing with earth history, and then he is forced to rely upon the picture provided by an integration of the results from these cooperative fields. Sometimes he has the good fortune, as we have had in Oregon, to find a stratified site that can be related to the geologic occurrences which deposited the sediments interrupting the course of human occupation. Then, if the date of this geologic occurrence can be fixed, it will serve as a reference point in time from which the archeologist can work.

Geologic History

The geologic history of the Great Basin has been studied fairly extensively since the early 1920's, with earlier investigations generally in the form of surveys of specific areas. G. K. Gilbert (in 1890) and Israel C. Russell (in 1885–86) provided the outstanding early accounts of the geologic history of Lakes Lahontan and Bonneville. In Oregon, G. A. Waring (1908–09) and Russell (1884) sup-

ROARING SPRINGS CAVE (CATLOW CAVE NO. 3) BEFORE EXCAVATION

plied important early information on the northern Great Basin. In recent years, Ernst Antevs has formulated a statement of the Postpluvial history of the Great Basin, and studies of glaciation have been carried out by F. E. Matthes, Eliot Blackwelder, and others. Henry P. Hansen, of Oregon State College, has incorporated analyses of the pollen profiles of northern Great Basin localities in his extensive study of Postglacial forest succession in the Pacific Northwest. Volcanism and its relation to the geological history of the Great Basin have been studied in greatest detail by Howel Williams. Various studies in sedimentation have been made by J. C. Jones, Ernst Antevs, and others. The most recent and most significant study in stratification for the whole Postpluvial picture is now under way by Ira S. Allison, of Oregon State College.

In Oregon there are seven basin lakes distributed from Klamath Lake in the west to the valley which held a shallow arm of Nevada's old Lake Lahontan, extending some 15 miles north of McDermitt in southeastern Oregon. Of these, all are typical basin lakes except Klamath Lake.

The post-Pleistocene climatic history is now thought of in terms of a series of fluctuations of precipitation and aridity. There are two theories underlying the studies of the chronology of the Postpluvial basin lakes. The first holds that each lake had its own history and therefore that a sound study could be made of the history of one lake without reference to that of any other. The only exponent of this theory with whose works I am familiar is the late J. C. Jones. Although Jones does not expressly state this theory, nevertheless it is implicit in his studies of Lake Lahontan in which he treats the history of that body of water as a phenomenon isolated from the general history of the Great Basin. The second theory, and the one to which all

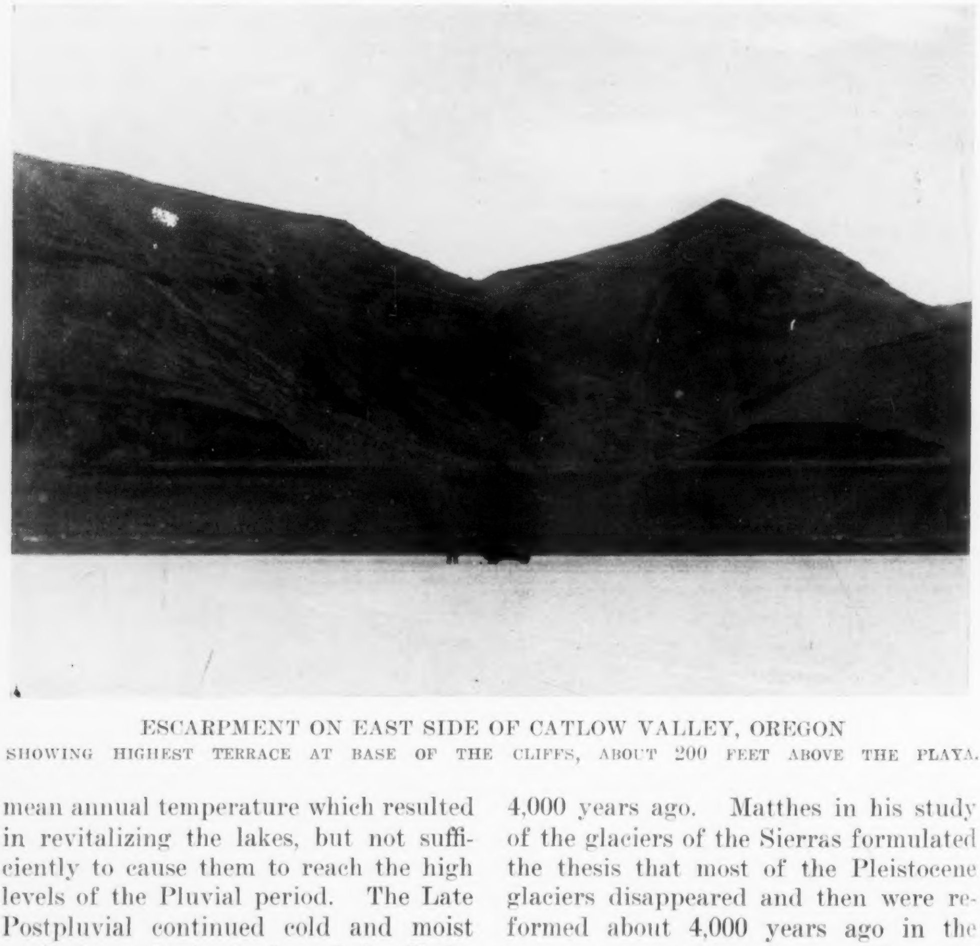
PAISLEY FIVE MILE POINT CAVE NO. 1
STRATIGRAPHIC BENCH RETAINED IN ORDER TO FACILITATE STUDY OF PUMICE STRATIFICATION.

other students of the problem adhere, is that the climatic changes covering long periods of time are cosmic in nature. This theory holds that the Great Basin represents a single province and that changes will be reflected throughout the whole province with minor fluctuations due to local situations affecting temperature, winds, and other factors. It also follows that climatic conditions in a great area such as this are local reflections of world-wide phenomena of climatic change. Therefore, we find Blackwelder attempting to correlate the glaciation of the Great Basin with that of the northeastern part of the continent. Matthes not only sees the history of the Basin as a unit but also correlates it with world-wide phenomena of glaciation and climatic change as reflected in records from Europe and other parts of the world. Antevs accepts this cosmic relationship of the climatic history of the Great Basin as the fundamental postulate for study of this subject. Among others who contributed to the subject, accepting this fundamental point of view, are Allison, Hansen, Kirk Bryan, John T. Hack, and Williams.

Antevs has formulated a Postpluvial climatic sequence and chronology. He divides the Postpluvial into the Early, Middle, and Late periods. The Early

period terminates about 7,500 years ago after a period of progressive desiccation and rising temperature. The Middle Postpluvial extends from about 7,500 years to 4,000 years ago and is marked by a period of greater aridity than any other time in the Postpluvial. During this period most of the lakes in the Great Basin dried up. By 4,000 years ago the Late Postpluvial begins, with an increase in precipitation and a drop in mean annual temperature which resulted in revitalizing the lakes, but not sufficiently to cause them to reach the high levels of the Pluvial period. The Late Postpluvial continued cold and moist until about the beginning of the Christian Era, when the climate became less moist and warmer, approximately what it has been since that time and what it is now. The more moist early half is sometimes referred to as the Little Pluvial.

Hoyt S. Gale, in his study of Owens Lake, estimated on the basis of the salinity of its water that the present lake dates from about 4,000 years ago. Walton Van Winkle studied Pluvial Lake Chewaucan in Oregon, consisting of what are now Summer and Abert Lakes, and concluded on the basis of the salinity of the water that they date from about 4,000 years ago. Matthes in his study of the glaciers of the Sierras formulated the thesis that most of the Pleistocene glaciers disappeared and then were reformed about 4,000 years ago in the western mountain systems. This conclusion is based on the small, very fresh moraines a short distance beyond the cirques. Hansen in his study of pollen profiles has found corroborative evidence



ESCARPMENT ON EAST SIDE OF CATLOW VALLEY, OREGON

SHOWING HIGHEST TERRACE AT BASE OF THE CLIFFS, ABOUT 200 FEET ABOVE THE PLAYA.

of the type of climatic sequences set forth by Antevs and on the basis of estimated rates of deposit of pollen-bearing sediments generally agrees with the chronology established by Antevs. Williams in his study of the history of Crater Lake has found that the utilization of the chronology formulated by Antevs, and agreed to by these other students, provides a satisfactory explanation for the time of the final incidents in the history of Mount Mazama. Probably the most important of all the studies establishing a chronology is that by Allison previously referred to, in which a continuous stratigraphic sequence from Summer Lake is analyzed. We have then a generally accepted chronology and sequential developments of the Postpluvial in the Great Basin accepted by a large number of distinguished experts to which the archeologist can appeal for the necessary assistance in establishing a chronology for Early Man in Oregon and the Great Basin.

ROCKS ON TALUS SLOPE
BELOW PAISLEY FIVE MILE POINT CAVE NO. 2. THESE FELL AFTER LEVEL OF LAKE SUBSIDED.

Archeological Evidence

Let us turn now to the archeological sites where definite evidence occurs by which the history of Early Man in Oregon may be fitted into the general pattern of Postpluvial history. The first is known as the Wikiup Dam Site No. 1, located on the Deschutes River about 30 miles southwest of Bend. Here two knives were found well under pumice from the final explosions which formed the crater in which Crater Lake now lies. Hereafter this source of pumice will be referred to as Mount Mazama pumice. Under the bed of pumice was one of sand mixed with pebbles, many of them highly stained with limonite. This had all the appearance of being glacial outwash. Under this bed was one of partly solidified sand about 4 inches thick, suggestive of hardpan in an early stage of formation. It was this bed from which the knives came. The level character of the bedding in this area is shown by the profiles from test pits made by the Bureau of Reclamation and indicates that the river had been dammed and that probably these sediments were laid down in a shallow lake. At any rate, the knives were deposited well before the Mount Mazama pumice was laid down. Later another knife, in general similar to those just described, was found in a test pit on the opposite side and about three-fourths of a mile farther up the river. This was also under Mount Mazama pumice and was in wash material including good-sized rocks. Consequently, it did not offer the same possibilities of dating as the first two.

A series of caves known as the Paisley Five Mile Point Caves, named from the local designation of the escarpment, where they were found 5 miles from Paisley in Summer Lake Valley, has provided the best stratigraphic evidence of Early Man in Oregon with reference

to the geological and paleontological framework. Two of these caves provide clear-cut evidence of interruption of their occupation by the deposition of pumice from the final Mount Mazama eruption. One of them, known as Five Mile Point Cave No. 3, contained deposits to a depth of about 7 feet. In the bottom of this cave were the remains of an old beach, sand, and water-smoothed pebbles. Partly embedded in the sand and extending into the debris above we found the remains of a campfire, worked obsidian implements, bones broken for their marrow, and the remains of *Equus*, camel, and several other mammals, including an undetermined species of bison. Over this bed was a series of deposits made up of fine dust, bat guano, and then coarser materials, perhaps weathered out of or shaken down from the roof and walls of the cave. On this in turn rested a bed of Mount Mazama pumice. Overlying the pumice was a bed spotted with evidence of occupation. Cave No. 1 was better for permanent occupation and showed continuous, although somewhat spotty, human occupation for a long time antecedent to the deposition of Mount Mazama pumice. Overlying the pumice was a bed of human occupation. We thus had in these caves a point of reference, namely, the eruption which deposited the pumice, from which dating could be attempted.

In the Fort Rock Valley, about a mile west of the remains of the volcano which gives its name to the valley, we excavated a cave in which the levels of the occupation were separated by a bed of pumice ejected at the formation of the Newberry Crater—another point of reference.

Lower Klamath Lake provided three horizons of human occupation, the earliest of which was associated with extinct fauna—*Equus*, camel, elephant, and possibly others. The remains of these animals, as well as the long bone projectile points used by the Indians, and a portion of a human mandible, were all fossilized and were all grouped around a relatively small area in what was apparently the last part of the lake to contain water before it dried up completely. The second horizon is associated with the refilling of the lake and is found at the south end at approximately 8 feet below the historic water level. This occupation was apparently terminated by the rising lake level. The third occupation represents the historic period of the Modoc Indians and is found around the lake shore and on the remains of the "islands" throughout the lake on which the Indians camped and hunted waterfowl. The method used in establishing the chronological sequences in this area has been to formulate the geological history of the lake and relate it to the Postpluvial history of the Great Basin. In this work the writer had the assistance of Antevs, W. D. Smith, and Allison. Hansen made an analysis of the pollen profile at the south end of the lake and at the Narrows, and at the south end the profile extended from well above to below the artifact horizon. As a result of his very careful study, we were able to corroborate the soundness of the earlier geological and climatological history of the lake as we had formulated it.

Correlating the Data

Paleontological evidence shows that man was in south-central Oregon living in caves around the lake shores along with a fauna now extinct, characteristic of the Pleistocene or Early Postpluvial. This fits into the geological and climatological picture and provides irrefutable evidence of human occupation of this area either in the Pluvial or Early Postpluvial period. The difficulty is, as I have mentioned above, in establishing the point of time at which this fauna became extinct. Extinction did not occur uniformly in time, but some of these animals must have lived on in more fav-

orable environments longer than their fellows in less favorable situations. Thus the evidence would seem to indicate that this fauna became extinct in the Lower Klamath Lake region sometime very near the end of the Early Postpluvial, or about 7,500 years ago.

Williams, in his study of the history of Crater Lake, fixed the time for the final eruption of the Mount Mazama pumice at a minimum of 5,000 years ago and a maximum of 10,000. It is not necessary here to go into the evidence he used to establish this chronology. However, a gap of 5,000 years in human history is of real importance to the archeologist, whereas it may be quite negligible to the geologist. At any rate, the evidence from the Paisley Caves and the Wikiup Dam Site locality shows conclusively that man was here considerably before the deposition of the Mount Mazama pumice.

Allison, in his study of the Summer Lake profile, fixes the date of the deposition of the Mount Mazama pumice at not less than 10,000 and perhaps as much as 14,000 years ago. This would therefore push back the date of the occupation of these Summer Lake caves by a considerable period. The pumice in the caves shows that it was deposited either directly from the air from the clouds of pumice thrown out at the explosion or else was blown in from heavy drifts at the mouth of the caves in the bottom of the escarpment. If the latter were the case, it must have fallen on snow-covered ground and been blown in before it could have had dust or other debris mixed with it (Dr. Allison has advanced this suggestion). Hansen's pollen profiles in general support the time estimates for the general chronological picture and the time of the deposition of the Mount Mazama pumice. If the date of the deposition of the Mount Mazama pumice is eventually fixed at 10,000 or 14,000 years ago, then we undoubtedly have evidence of man in the northern Basin dating from probably 15,000 years ago. Thus archeology in collaboration with these other sciences has established an integrated and coherent picture of the Paleo-Indian in Oregon in the Early Postpluvial and continuing to the present.

L. S. CRESSMAN

L. S. Cressman, Ph.D., is Head of the Department of Anthropology and Director of the Museum of Natural History at the University of Oregon. He was born near Pottstown, Pa., October 24, 1897. His B.A. degree was taken in the classics at Pennsylvania State College in 1918. Brief service in the armed forces followed with a commission in the Field Artillery Reserve Corps. He received his Ph.D. at Columbia University in 1925. The next year was spent traveling and studying in Europe. After teaching at the College of the City of New York, he went west in 1928, spending a year teaching at the Ellensburg Normal School in the state of Washington. The following year he went to the University of Oregon. From 1931 through 1940, with the exception of 1936, he has carried on archaeological field work in Oregon. In 1940–41 he was a Guggenheim Fellow studying and preparing for publication a monograph, *Archaeological Researches in the Northern Great Basin*, published in 1942 by the Carnegie Institution as Publication 538. Since the outbreak of the present war he added civilian defense activities to his regular university duties, both in aircraft warning service and on the conservation of cultural resources of Oregon.

EARLY MAN IN OREGON

POLLEN ANALYSIS AND POSTGLACIAL CLIMATE AND CHRONOLOGY*

By HENRY P. HANSEN

DEPARTMENT OF BOTANY, OREGON STATE COLLEGE

SCIENTISTS are constantly delving into the past, seeking to reconstruct the life, climate, and events of prehistoric time, seizing upon any evidence, however minute, to find and fit in a piece of this gigantic paleontologic jigsaw puzzle. This picture of past life, conditions, and events is being projected farther and farther into the past as more evidence comes to light. The farther back one goes, however, the more fragmentary becomes the record, and so the picture of prehistoric life must be portrayed in terms of millions of years. There are three chief problems involved. The first is to find the evidence or record, the second is to interpret the record, and the third is to fit the fragments into a systematic and logical chronology. To do this the chronologist must analyze the record and the interpretations of many scientists in diverse fields. Some events readily fall into their chronological niche, while others are fitted into a sequence with more painstaking and laborious effort. The more conspicuous and widespread time markers provide a means of dividing prehistoric time into a series of large segments for vast regions. More obscure and local time markers help to fill the gaps for limited areas. The shorter periods of time for smaller areas must then be correlated with those from other localities, and an integrated timetable constructed. The units of this chronologic column are largely relative, and it does not seem probable that absolute chronology will ever be attained except for local areas. However, the more segments into which this column can be accurately divided, the more nearly absolute the chronology becomes. In the Pacific Northwest, the cooperative efforts of geologists, archeologists, and botanists have resulted in at least a partial picture of life, climate, and events, and the development of a tentative, relative chronology for postglacial time.

POLLEN ANALYSIS

The most important source of evidence for prehistoric life is the fossil record. It has been said that the paleontologist can reconstruct a prehistoric monster on the basis of a bone of its little toe. Whether this be true or not, the paleobotanist reconstructs prehistoric vegetation with more minute evidence than that. This does not mean a lesser amount of evidence, but rather that the fossils involved are much smaller. The pollen grains of plants are one of the most valuable of these microfossils. One of the routine processes in the life of a flowering plant is the production of almost countless numbers of pollen grains each year from the time of its maturity until it dies. If the plant is an annual or biennial, it may produce pollen only once, whereas if it is a tree it may produce pollen for several centuries. Some of this pollen is the same that causes hay fever in man, and many persons are acquainted with pollen grains only through this unpleasant experience. The pollen of some plants is disseminated through the air in order to reach its objective, the pistil of a flower

* From a paper presented at a symposium on Early Man in Oregon at the annual meeting of the Oregon Academy of Science, Portland, Ore., January 13, 1945.

of the same species. The pollen grains of other plants are large and sticky, cohere in masses, and must be carried by insects if cross-pollination is essential. The air-borne pollen grains are well protected by a thick outer coat and a thinner inner coat, so as to retain their viability for a long time. Pollen grains have been noted thousands of feet high in the atmosphere and hundreds of miles out at sea.

The pollen grains of various groups of plants differ considerably in shape, size, and external configuration. It is possible to separate the principal families, genera, and even species by their pollen grains. After some study one can distinguish pine from fir, spruce from hemlock, oak from alder, etc. In the Pacific Northwest it is possible to distinguish to a reasonable degree of accuracy the pollen of some species of pine and fir, while it is a simple matter to differentiate between pollen of western and mountain hemlock, Sitka and Engelmann spruce, Douglas fir and larch, and many others. Certain groups like the grasses are almost impossible to separate specifically, and so one must be content to interpret the record of fossil grass pollen on the basis of a group.

Down through the ages plants have shed their pollen annually, and in certain favorable sites much of this pollen has been preserved in the accumulating sediments. Analysis of these sediments for their fossil pollen record provides the paleobotanist with a basis for reconstructing the past vegetation. It not only furnishes qualitative evidence but also a quantitative record, something that most fossil records do not. Their preservation in postglacial organic sediments provides, perhaps, a more intensive, detailed, short-period record of the changes and adjustments in prehistoric vegetation than any other type of fossil.

Pleistocene glaciation has been most important in furnishing sites for the preservation of the pollen record. Not only has this well-defined geologic event been instrumental in making possible the preservation of the fossil evidence, but it also provides a significant time marker for the beginning of the record. As the last glaciers retreated from the United States, many lakes and ponds were left in their wake. In fact, most of our lakes owe their origin directly or indirectly to glaciation, whether they lie within or beyond the boundaries of glaciation. The inevitable fate of any lake, large or small, is to become filled with either organic or inorganic material, or both. In the North Temperate Zone, the smaller lakes have become entirely filled with peat, and in many cases their sites are forested so as to obliterate any surface evidence of their former existence. Others are in various stages of swamp or bog formation or other processes of filling. Peat consists of undecayed vegetable matter, composed largely of plants and other organisms that lived first in the open lake and then in the bog that followed. Various groups of plants encroach upon a lake in definite order. First invaders are the submerged species, which are followed by floating species. As the plants die their remains are contributed to the accumulating bottom sediments which are also being added to by incoming inorganic materials. As the water is shoaled by these sediments, rooted aquatics replace them, and this marks the beginning of the end of the lake. An immature bog may have open water in the center, surrounded by concentric zones of vegetation. When the center of the lake is reached by these encroaching plants, there is no place to migrate and they are gradually eliminated by the succeeding zone, and so on. Eventually the lake is covered, and bog or swamp vegetation consisting of sphagnum moss, heaths, reeds, rushes, and

sedges covers the entire site. In the meantime, perhaps many feet of peat have been built up. The coldness and acidity of the water and substratum provide an aseptic medium for the almost perfect preservation of the cellular structure of the plant tissues. Among the plant cells preserved are numberless pollen grains that drifted into the lake and later the bog. They are usually so well preserved that the trained observer can distinguish many of them even as to the species they represent. Year after year, decade after decade, and millennium after millennium a rain of pollen from the adjacent forests has settled on the lake or bog and has become incorporated into the accumulating sediments. The pollen is disseminated to great distances, so that the forests that have existed within a radius of 50 miles may be well represented. Time of pollen shedding, direction of the wind, receptivity of the lake or bog, degree of preservation, relative amounts of pollen produced from the various species, as well as many other factors enter into the accuracy of the record.

In order to analyze and interpret the record, a sedimentary column is obtained, beginning with the silts and sands of the earliest lake bed and extending to and including the surface peat. This is done with a peat sampler, which is so constructed that an uncontaminated sample of a few cubic inches can be obtained at any interval desired. The magnitude of the sampling interval is determined by the depth of the bog; the greater the depth the greater the interval used. A 10-foot section of pollen-bearing sediments may be chronologically equivalent to a 50-foot column from another bog. A small portion of the sediments from each level, a cubic centimeter or so, is chemically treated in order to deflocculate the pollen grains from the rest of the organic matrix, stained, and mounted in glycerin jelly on a microslide. From 100 to 200 pollen grains of indicator species are identified from each level. Fortunately most

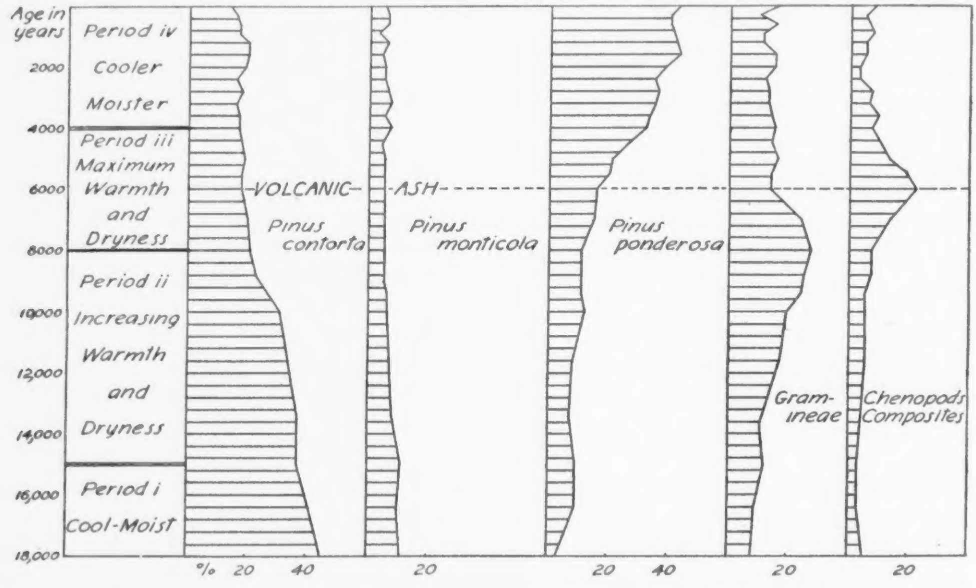


FIG. 1. POLLEN PROFILES, EASTERN WASHINGTON REGION
FOR LODGEPOLE, WESTERN WHITE AND YELLOW PINES, GRASSES, CHENOPODS, AND COMPOSITES.

of our trees have air-borne pollen, and they have left an excellent record in the peat columns. The trees of a forested area are the best indicators of climate and other factors of the environment. In unforested areas, grasses, composites, and chenopods are valuable indicators in the Pacific Northwest, and pollen from these groups is abundant in sedimentary columns from the timberless areas of eastern Washington and Oregon. Many pollen grains of less important species are present, but these have little or no index value in reconstructing the vegetation of the past.

The percentage of pollen for each indicator species for each level is determined. From these data a curve is constructed for each species, revealing its fluctuations during the time represented. Some trees are more abundantly and consistently represented and provide the most significant data for interpretation of the past forests. A given species may be predominantly represented in the lower levels of the column, and then its pollen become less and less upward in the profile until it is almost or entirely absent near the surface (Figs. 1, 2). Other species may not be recorded in the bottom levels but become predominantly represented before the surface is reached. These fluctuations in the proportions of pollen grains of the several species upward in the column reflect the changes in forest composition during the postglacial time as the environmental conditions changed. In a few cases the forest succession thus recorded merely indicates a natural development toward the climax or ultimate type of vegetation that can be supported by the area, involving little climatic change. In other words, vegetation itself modifies the environment and paves the way for continued plant succession, such as mentioned above in bog succession. Slight changes in the pollen proportions of a species from level to level do not indicate changes in the forest composition unless these trends are sustained for several horizons. Minor

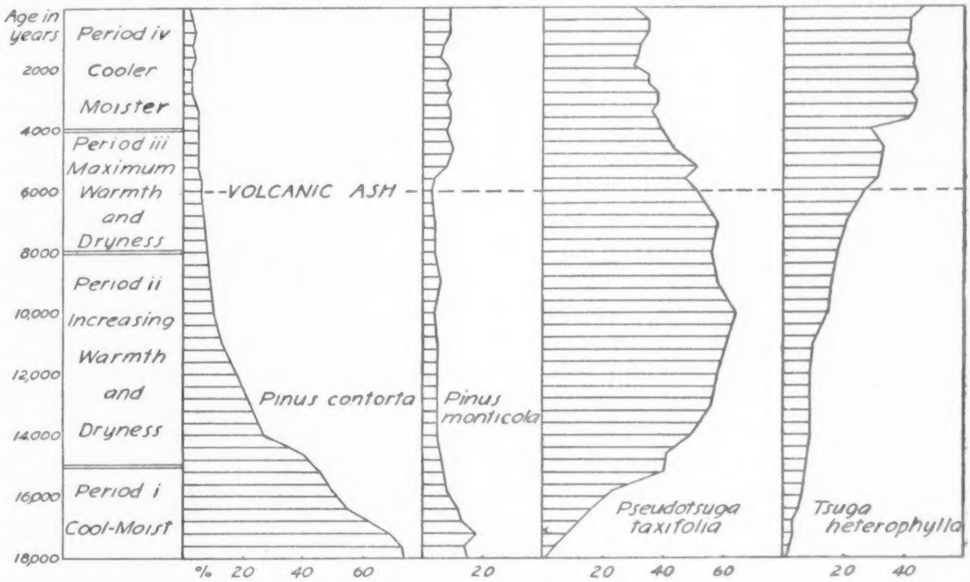


FIG. 2. POLLEN PROFILES, PUGET SOUND REGION
FOR LODGEPOLE AND WESTERN WHITE PINES, COMMON DOUGLAS FIR, AND WESTERN HEMLOCK.

fluctuations, back and forth, are peculiar to the method of pollen analysis. It is the greater and long-range trends that indicate change in vegetation complex, which in turn suggests environmental fluctuation. Sometimes sharp fluctuations from one level to the next denote an abrupt change in the environment, such as those caused by fire, volcanic eruptions, or other catastrophic events that destroy the vegetation and suddenly change the trend of succession.

The principle of fossil pollen analysis is simple in itself; the interred record is obvious and easily accessible, but it did not receive the systematic and concentrated attention of scientists until recently. Although the earliest known work in fossil pollen analysis was done by a Swiss scientist in 1865, it was not until 1916 that Swedish scientists applied the method in working out the postglacial vegetation of northern Europe. In North America this method was first used as early as 1927, but it was not until the thirties that sufficient investigations were being conducted to give any significant results. The future of this paleobotanical method is bright, and more and more applications of its results will be made. Its most recent application is to American archeology, and it may serve to shed much light on the prehistory of man in North America.

Chronological Criteria

The most recent, systematic, and widespread major time marker is Pleistocene glaciation, which occurred during the past million years in the Northern Hemisphere. The time since the last of these great ice sheets reached its greatest advance and began its final retreat is estimated by geologists to be about 25,000 years. In the Pacific Northwest, the Puget Lowland of western Washington and the northern part of that state east of the Cascade Range were covered with glaciers that are considered to be of the same age as those of north-central and eastern United States. Mountain glaciation also occurred in the Cascade Range of Oregon and Washington; the major movements of these were probably generally contemporaneous with those of the continental glaciers. All pollen-bearing sediments that rest upon glacial drift or its chronological equivalent are necessarily postglacial in age. It is doubtful, however, that the vegetation history recorded in the peat columns goes back to immediate deglaciation of a given site, because of delay in sedimentation and/or the absence of forests within range of pollen dispersal. Occupation of the basins by dead ice for some time after the main body had wasted, as well as other conditions brought about by the unstable physiographic situations existent in deglaciated areas, is responsible for an incomplete record. Another factor causing a possible time differential for the beginning of sedimentation in different areas is the rate of ice retreat. It may have taken several thousands of years for the ice to waste back from the point of greatest advance to its center of accumulation. Because of these and still other factors, all immeasurable as to time, the average age of the pollen-bearing sediments in the Pacific Northwest, resting upon glacial drift or its chronological equivalent is estimated at about 18,000 years. Some may be younger and others older, depending upon their locations with respect to the position of the glacial termini and subsequent geomorphic cycles. Many postglacial sedimentary columns lying beyond the limits of glaciation are probably of the same age, because they rest on materials that owe their emplacement indirectly to glaciation, as by inundation of their sites by glacial waters, impounding water in tributaries by aggrading of main stream valleys, and eustatic changes in sea level caused by nurturing and wasting of glaciers, and

POSTGLACIAL CLIMATE AND CHRONOLOGY

YEARS AGO	SWEDEN	EASTERN NORTH AMERICA			GREAT BASIN	PACIFIC NORTHWEST	ASH and PUMICE
	SUB-	COOLER-MOISTER					
1,000	ATLANTIC COOLER	OAK-CHESTNUT SPRUCE				PERIOD IV	
2,000	MOISTER	(oak-beech)		LATE	COOLER-MOISTER	COOLER-MOISTER	
3,000	SUB-BOREAL	WARM-DRY TEMPERATURE MAXIMUM					
4,000	WARM-DRY	OAK-HICKORY					Devils Hill pumice
5,000	ATLANTIC	WARM-MOIST	POSTGLACIAL			PERIOD III	Willamette Valley pumice
6,000	WARM-MOIST	OAK-HEMLOCK		MIDDLE	MAXIMUM WARMTH and DRYNESS	MAXIMUM WARMTH and DRYNESS	Washington Volcanic ash
7,000		(oak-beech)					
8,000	BOREAL	WARM-DRY PINE					NEWBERRY CRATER Eruption
9,000	WARM-DRY	PRE-BOREAL COOL-MOIST SPRUCE-FIR		EARLY	INCREASING WARMTH and DRYNESS	PERIOD II	
10,000	SUB-ARCTIC COOL						
11,000		HUDSONIAN					
12,000					RISING TEMPERATURE	INCREASING WARMTH and DRYNESS	MOUNT MAZAMA Eruption
13,000	ARCTIC COLD			YOUNGER			
14,000			LATEGLACIAL		DECREASING MOISTURE		
15,000							
16,000		PRE-HUDSONIAN			SUBSIDING LAKES		
17,000				MIDDLE		PERIOD I COOL-MOIST	
18–20,000							

the modified marine cycles and shoreline processes resulting therefrom.

Many alpine and montane bogs in the Pacific Northwest are underlain with drift from mountain deglaciation. Because of a probable lag in deglaciation at these higher elevations, these sediments are slightly younger than those that lie on continental glacial drift. An average age for these is estimated to be about 15,000 years.

A second but more local series of time markers is postglacial volcanic activity as revealed by one or more layers of ash or pumice in Pacific Northwest sedimentary columns. Perhaps the most spectacular and evident is the eruption of Mount Mazama, which formed the caldera holding Crater Lake in the southern Cascades of Oregon. This great eruption dispersed pumice over some 5,000 square miles to the north and east of Crater Lake, which provides a common time marker for the pollen-bearing sediments that rest on the pumice, and for those at greater distance that contain an interbedded stratum. Dr. Howel Williams, of the University of California, has dated this eruption at 4,000 to 7,000 years ago, a figure which finds support in the limited amount of organic sedimentation which has occurred since. Dr. Ira Allison, of Oregon State College, by correlating lake beds in south-central Oregon containing Crater Lake pumice with postglacial fluctuations of Great Basin lakes, concludes that it occurred between 12,000 and 14,000 years ago. Upon the basis of the depth of pollen-bearing sediments and the recorded forest succession, the writer believes that the eruption of Mount Mazama did not occur more than 12,500 years ago, and probably somewhat later (see table). This preceded the eruption of Newberry Crater located about 70 miles to the northeast of Crater Lake, as shown by the position of its pumice layer above those from Mount Mazama in the lake beds of south-central Oregon (table). Pumice from this source has not been found in bogs in the Cascades, as its dispersal was both local and to the east of the main Cascade Range.

More recent and lesser eruptions of volcanoes in the Three Sisters area of the central Cascades of Oregon have deposited local pumice mantles. A few bogs lie on pumice from an eruption of Devils Hill, which the writer has set at about 4,000 years based upon the thickness of the overlying pollen-bearing sediments and the forest succession recorded therein (table). That this eruption followed that of Mount Mazama by thousands of years is shown by the occurrence of its pumice at 2 meters and the presence of a stratum of Mount Mazama pumice at 4.5 meters in a 7-meter profile 13 miles west of Bend, Ore.

In the Willamette Valley of northwestern Oregon, a layer of pumice is present in the upper third of most peat sections. Examination reveals that it did not come from Mount Mazama. Its position immediately above an oak maximum recorded in the profiles, signifying a warm, dry climate, suggests that the eruption providing the pumice occurred much later than that of Mount Mazama. This pumice may have come from Mount St. Helens in southwestern Washington, about 100 miles to the north. The writer has estimated this volcanic activity at about 5,000 years (table).

In most bogs in the state of Washington, with the exception of those along the coast and in the southwestern part, there occurs a single layer of fine, volcanic ash which may have come from Glacier Peak in the north-central part of the state. This is the most valuable time marker resulting from volcanic activity in the Pacific Northwest because of its widespread occurrence and presence in so many postglacial sedimentary columns. The position of the ash stratum in the sedimentary columns is usually at a level

from two-thirds to three-quarters down from the top. The average thickness of 30 sections resting upon glacial drift or its chronological equivalent is about 7.2 meters, and the average depth at which the ash occurs is 4.4 meters. The stratigraphic position of the ash near the culmination of a warm, dry period as interpreted from the recorded forest succession, suggests that the volcanic activity occurred about 6,000 years ago (table; Figs. 1, 2).

A third factor that has indirectly provided chronological criteria for postglacial vegetation history in the Pacific Northwest is the fluctuations in the levels of the Great Basin lakes. During the last glacial (pluvial in the Great Basin) stage, the levels of Lake Bonneville, antecedent of modern Great Salt Lake, and of Lake Lahontan, predecessor of modern Pyramid Lake in western Nevada, were higher than the modern lakes. They perhaps reached their last high levels during the Tioga glacial stage of the Sierra Nevada of California. This is probably equivalent to the last Wisconsin glacier, which in turn is considered to have been contemporaneous with the final glacial stage in the Puget Lowland and eastern Washington. As mentioned above, the culmination of this stage was reached about 25,000 years ago, the maximum age of Pacific Northwest postglacial sedimentary columns. As the glaciers receded and the climate became drier, both Lake Bonneville and Lake Lahontan apparently dried up during the peak of the drought. The modern lakes, Great Salt Lake and Pyramid Lake, are thought to have been formed later when there was a general increase in precipitation over the Northern Hemisphere. Dr. Antevs believes that this period of extreme desiccation occurred between 8,000 and 4,000 years ago, and he has named it the warm, dry Middle Postglacial (table). The lakes of south-central Oregon, in the northern part of the Great Basin, seem to have had a somewhat similar history as shown by Dr. Allison in the following article in this issue. It is the presence of pumice from Mount Mazama and Newberry Crater in the dry bed of Lake Chewaucan, Pleistocene antecedent of modern Summer Lake, correlated with this evidence for fluctuating lake levels, that furnishes a connecting link between the Great Basin and the Pacific Northwest with respect to postglacial climatic trends. Further evidence for this warm, dry period is offered by the salinity of Owens Lake in California and of Abert and Summer Lakes in south-central Oregon. The present salinity of these lakes need not have required more than 4,000 years to have been attained. As these lakes lie in closed basins, there is no chance for the incoming salts to be lost, so that as time goes on their water develops a greater concentration of dissolved salts. These lakes apparently dried up during the warm, dry Middle Postglacial, and the sediments were buried or removed by deflation. The lakes were reborn with the advent of more moisture about 4,000 years ago, and since have become more saline.

A fourth line of evidence lending support to the termination of a dry period about 4,000 years ago is found in the history of western mountain glaciers. With the exception of the main trunk glaciers, which have persisted since the Pleistocene, many glaciers in the Sierra Nevada were born about 4,000 years ago, according to glacial geologists. This suggests that most of the Pleistocene glaciers disappeared during the warm, dry Middle Postglacial, and their present successors were initiated with an increase in moisture about 2,000 years B.C.

Postglacial Climate

Much evidence has accumulated for the occurrence of at least one warm, dry period in the North Temperate Zone

during postglacial time. In Scandinavia typological succession in peat bogs correlated with varved clay chronology has been interpreted to mean that there were three warm stages of alternating dryness and moisture during the past 15,000 years. Application of the absolute chronology of varved clays has dated these as occurring between 9,000 and 2,600 years ago. Varved clays are annually banded sediments that were deposited in glacial lakes during glacial retreat. The rate of ice retreat has been determined by counting the varves and cross-dating them with varves from lakes formed successively in the wake of the retreating ice. In eastern North American pollen profiles, trans-Atlantic correlations have been applied, and interpreted as reflecting the occurrence of these three warm periods about the same time. Von Post, a Swedish scientist, upon the basis of pollen analytical data from Scandinavia, has divided the Postglacial into three climatic periods. The first was one of increasing warmth, the second was one of maximum warmth, and the third was one of decreasing warmth. He believes that after glacial retreat the temperature gradually rose and attained its maximum between 7,000 and 6,000 years ago. He includes the time represented by the three warm periods mentioned above in an "Age of Warmth" but does not interpret alternating dryness and wetness. The von Post sequence has been applied to pollen profiles in England and also to eastern North American pollen profiles by some American workers. A somewhat modified scheme seems to fit the pollen profiles of the Pacific Northwest.

Pollen analytical data from 65 postglacial sedimentary columns, correlated with the time markers and climatic evidence mentioned above, reveal that there were four periods of climatic trends in the Pacific Northwest. Period I, persisting from deglaciation until about 15,000 years ago, was cool and moist, owing to the influence of recent glaciation. Period II was one of increasing warmth and dryness, lasting until about 8,000 years ago. Period III marks the stage of maximum warmth and dryness which endured until about 4,000 years ago. This stage marks a period of maximum warmth and dryness which was perhaps general over the entire Northern Hemisphere. It was during this time that the Great Basin lakes dried up or reached their lowest levels. This stage may be designated as the warm, dry Middle Postglacial. Period IV saw a return to cooler and moister conditions which with minor fluctuations have persisted to the present (table).

These climatic stages are perhaps most sharply defined by the vegetation history recorded in the sedimentary columns in eastern Washington. In this region, the marine climate of the Coastal Strip and Puget-Willamette Lowland is considerably modified by the Cascade Range and the continental influence to the east. The rainfall is at a critical minimum for forest growth, permitting contraction or expansion of forested areas with only slight changes in precipitation. In pollen profiles from this region, the maxima of grasses, chenopods, and composites for a period beginning before, and continuing for some time after, the recorded volcanic activity marks an expansion of the timberless area due to the warming and drying during the Middle Postglacial (Fig. 1). Western yellow pine, the present climax dominant, rapidly expanded above the volcanic-ash stratum, indicating increased moisture and expansion of the forested zone. The attainment of the yellow-pine climax was apparently held in abeyance by the continued warming and drying until about 5,000 years ago.

In the Puget Sound region the four climatic periods are not so well portrayed by the forest history because of

the greater amount of precipitation and the wide range of environmental conditions tolerated by one of the principal species, Douglas fir. This species is the principal timber tree of the Pacific Northwest. The chief dominant species in the Puget Sound region is western hemlock, which requires more moisture and better soil conditions than Douglas fir. The latter is a subclimax tree that has been able to persist as one of the most abundant species because of recurring fire down through the centuries. If forest succession is permitted to continue without interruption, hemlock gradually becomes the most abundant arboreal species, and Douglas fir is crowded out entirely. The development of western-hemlock postglacial predominance was held in check until sometime after the volcanic activity, first by the unfavorable soil conditions and then by the warming and drying of the Middle Postglacial. The maximum and predominance of Douglas fir occur below the level of the volcanic-ash stratum in most Puget Sound region pollen profiles, while the maximum and predominance of hemlock do not occur until above the ash layer (Fig. 2). The retardation of the development of the hemlock supremacy may have been partly influenced by fires, which tended to favor the persistence of Douglas fir as the most abundant arboreal species.

In the central Oregon Cascades the climatic record in the pollen profiles is somewhat obscured by the influence of a thick pumice mantle upon forest succession. In areas where the pumice is several to many feet thick, the vegetation was destroyed, and the subsequent forest succession has apparently been controlled by the sterile, pumiceous soil. In areas where the pumice fall was lighter, the vegetation was not entirely or immediately destroyed, but a well-developed trend toward a yellow-pine climatic climax was interrupted, and lodgepole pine superseded it and has since remained predominant. Lodgepole pine is the most common tree in Yellowstone National Park. This is well shown in pollen profiles from a peat bog at Tumalo Lake, 13 miles west of Bend, Ore., where two layers of pumice, one from Mount Mazama and the other from Devils Hill, are interbedded in the peat column. In areas southwest of Crater Lake, where the pumice is confined largely to the valley floors, western yellow pine has been predominant since the eruption of Mount Mazama. It attained its maximum in the lower third of the profiles marking the culmination of the warm, dry stage. As these columns rest directly upon Mount Mazama pumice, the warm, dry maximum must have followed the eruption of Mount Mazama by several thousands of years. Two bogs lying upon glacial drift north of the pumice mantle in the Oregon Cascades, reveal that lodgepole pine was the pioneer postglacial invader, the same as in the Puget Sound region and in eastern Washington. The yellow-pine maximum, marking the warm, dry stage, was attained in the middle third of the profiles. A return to moister conditions is reflected in the marked increase in western hemlock and a correlative decline in yellow pine in the upper third of both profiles. As these sections probably represent most of postglacial time, or about 15,000 years, the eruption of Mount Mazama could hardly have taken place more than 15,000 nor less than 8,000 years ago.

In the Willamette Valley of northwestern Oregon the warm, dry Middle Postglacial is indicated by a high maximum of Oregon white oak, which was able to supersede Douglas fir for a brief interval. As oak is the most xerophytic arboreal species in the Willamette Valley, its predominance at these levels supports the other evidence for the warm, dry interval. Its later decline and an increase in Douglas fir denote the return

of moister conditions in more recent time. In the northern Great Basin of south-central Oregon, the evidence of Early Man provides further chronological data which are readily correlated with the history of postglacial vegetation. In four peat columns from Lower Klamath Lake, which probably represent most of post-Mount Mazama time, the pollen profiles reveal evidence for a warm, dry stage, which upon the basis of stratigraphy may be inferred to have been contemporaneous with the warm, dry Middle Postglacial. Also, the occurrence of an artifact horizon in one of the sedimentary columns, at or near the level denoting maximum warmth and dryness, suggests that the lake dried up so that Early Man camped along a slough or stream that flowed through the exposed lake bed. Hence man was in the Klamath Basin 4,000 or 5,000 years ago. Upon the advent of moister conditions, the lake bed was re-inundated and 6 to 8 feet of peat was deposited over the artifacts.

That Early Man was in south-central Oregon as early as 12,000 years ago, or prior to the eruption of Mount Mazama, is revealed by the occurrence of artifacts under the pumice in caves, and the presence of obsidian knives beneath the pumice at the Wikiup Dam Site on the Deschutes River about 30 miles south of Bend, Ore. The importance of this evidence is well shown by Dr. Cressman, of the University of Oregon, in his companion paper in this issue.

The work of Williams, Antevs, Allison, and Cressman has been most valuable in reconstructing the chronology of climate and of the postglacial vegetation in the Pacific Northwest. It shows how the results of several phases of scientific research help to fill in some of the pieces of the paleontologic jigsaw puzzle, which is entombed in the archives of the earth.

INTO THE ROCK

Another footprint shall we be
In rock that held for history
The tusk of giant mastodon
That sweating jungles bore upon . . .
Where lizard slid from slime to stone,
Where fighting dinosaur left bone
And carrion gave to bat-like bird
Mid sounds no human ear has heard . . .
There lava poured its scorching death
Before the glacier's icy breath
Laid waste the land, swept to the sea,
Till nothing lived of fern and tree,
Save only, in terrain, the core
That fought through chaos gone before
When planets to their orbits swung
And from the dark thin light was wrung . . .
God will not let man's footprint fail,
Though wars may blaze till stars grow pale,
Who walked this way and stood erect,
Tasting the world with intellect!

Barbara Whitney

EARY MAN IN OREGON

PLUVIAL LAKES AND PUMICE*

By IRA S. ALLISON
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As evidences of Early Man in Oregon were discovered by Dr. L. S. Cressman, of the University of Oregon, to underlie air-laid pumice in caves excavated by waves on the shores of extinct lakes that once occupied the Fort Rock, Summer Lake, and other fault basins in south-central Oregon, it became important to trace the pumice to its sources and to determine as completely as possible the history of those ancient lakes. Dr. Howel Williams, of the University of California, who was studying the volcanic history of the Crater Lake region, identified the pumice in the caves near Paisley, Ore., as the product of former Mount Mazama (on the present site of Crater Lake) and the pumice in the cave near Fort Rock, Ore., as the product of Newberry Volcano. Dr. Ernst Antevs, research associate of the Carnegie Institution of Washington, following a brief reconnaissance assigned the caves and other shore features to the Pluvial or Glacial Age, as had Russell, Meinzer, and others many years ago. At the request of Dr. John C. Merriam, late president emeritus of the Carnegie Institution of Washington, the writer in 1939 undertook a field investigation so as to provide a more complete geologic framework into which the archeological data could be fitted. Subsequently these studies have continued through parts of several field seasons.

Pluvial History of the Great Basin

The prototypes of these various pluvial lakes are described in the classic works of G. K. Gilbert on Lake Bonneville and of I. C. Russell on Lake Lahontan. Lake Bonneville is an extinct lake that at its maximum stage was more than 1,000 feet deep and covered more than 19,000 square miles in the eastern part of the Great Basin in western Utah and eastern Nevada. Its shore features are clearly shown around its margin, especially against the western foothills of the Wasatch Range in Utah, as at Salt Lake City, Provo, Logan, and elsewhere.

Lake Bonneville had two distinct high-water stages, about 1,000 and 625 feet deep, respectively, which were named by Gilbert the Bonneville and Provo stages. They were separated by a stage of comparatively low water, presumably caused by a change toward a drier climate. Recent interpretations correlate these maximum stages with the Tahoe and Tioga glacial stages of the Sierra Nevada of California, which in turn seem to be equivalent to early Wisconsin (Iowan) and late Wisconsin (Mankato) glacial stages of the north-central United States. Their culminating stages, therefore, were reached about 65,000 and 23,000 years ago.

Former Lake Lahontan in western Nevada, which once covered nearly 9,000 square miles and stood about 530 feet higher than modern Pyramid Lake, had a similar history.

Both Lake Bonneville and Lake Lahontan are thought to have disappeared by desiccation several thousand years ago as a result of extreme drought, and the modern lakes such as Great Salt Lake and Pyramid Lake are thought to have been formed later, because of a change to somewhat moister, though still semiarid, conditions.

* From a paper presented at a symposium on Early Man in Oregon at the annual meeting of the Oregon Academy of Science, Portland, Ore., January 13, 1945.

Thus from the climatic standpoint these former lakes indicate two stages of moist or pluvial climate, each followed by a stage of reduced precipitation (or increased evaporation, or both), and the modern lakes indicate a slight return to pluvial conditions in recent millennia.

Evidence from Fort Rock Basin

The Fort Rock basin is a fault-block depression in the northern part of the Great Basin in south-central Oregon. It too has a record of an early pluvial lake about 230 feet deep and of a later one about 140 feet deep. Waves on the lake of the 140-foot, or Provo, stage, which the writer calls pluvial Fort Rock Lake, eroded the cave near Fort Rock in which Cressman found the artifacts of Early Man beneath a blanket of pebble pumice derived from Newberry Volcano.

Studies of the sediments on the former bottom of the lake by the writer disclosed that the Newberry pumice fall occurred when Fort Rock Lake, once 140 feet deep, had been reduced by evaporation to a depth of about 30 feet and that the lake entirely disappeared shortly afterward. If one assumes that the 140-foot stage was reached about 23,000 years ago and that the lake in its waning stage persisted until about 10,000 years ago (a short time prior to the dry climatic stage of 8,000 to 4,000 years ago) the age of the Newberry pumice and hence of the human occupation of the area is carried back to about 11,000 or 12,000 years ago.

During the later dry stage the wind excavated basins in the lake plain which range in depth from a few feet to 40 feet or more and in area from a fraction of an acre to several hundred acres. Several of these deflation basins later became the sites of small lakes or ponds. Subsequently, such lakes have dried up and deflation on a moderate scale has been resumed. Thus the basins give evidence of post-Pluvial climatic history as follows: (1) Decreasing moisture, increasing aridity, and increasing wind work, that reached a maximum probably during the dry stage of 8,000 to 4,000 years ago, (2) increased precipitation, cessation of deflation, and formation of small lakes in the basins previously excavated, some 2,000 years ago, and (3) later return to somewhat dry conditions and partial renewal of wind erosion.

Clues from Summer Lake Basin

Summer Lake basin in south-central Oregon is another fault-block depression with an area of about 200 square miles, of which modern Summer Lake, shallow and alkaline, covers about 50 to 70 square miles. In this basin pluvial Lake Chewaucan of the Bonneville, or Tahoe, stage stood about 350 feet higher than Summer Lake is now, and pluvial Winter Lake of the Provo, or Tioga, stage was about 210 feet deeper.

The artifact- and fossil-bearing caves near Paisley, Ore., which contain an air-laid stratum of sandy Mount Mazama (Crater Lake) pumice above the artifacts and fossils, belong to the early high-water level.

The sediments of the pluvial lakes, partly exposed in the short valley of Ana River at the north end of the basin, include a series of lake-laid pumice or ash falls. Certain of these are correlated by petrographic criteria with eruptions of Mount Mazama and a later one with the eruption of Newberry Volcano. At the time of the climactic outburst of Mount Mazama pluvial Winter Lake, formerly 210 feet deeper than Summer Lake, was still about 85 feet deeper. Hence the distribution of the pumice took place before the end of Pluvial time. If the last pluvial lake attained its maximum level about 23,000 years ago and disappeared about 10,000 years ago, the age of the main Mount Mazama pumice fall, as indicated by the

80 to 90 foot depth of the lake then existing, must be about 12,000 to 14,000 years. The artifacts underlying the pumice in the caves nearby then must be older yet.

As the pumice in the Paisley caves is in places 18 to 24 inches thick, whereas the corresponding water-laid material on the lake bed is only about 8 inches thick, the possibility that the pumice was drifted into the caves by the wind, perhaps long after the original fall, has to be considered. Evidence against such a secondary eolian origin includes: (1) The purity of the pumice, (2) the difficulty of transporting the pumice particles up hill over or through a coarse boulder field to an elevation about 100 feet higher than the edge of the lake plain, (3) the presence of large numbers of crystals of feldspar and hypersthene that should have been winnowed out from the light pumiceous glass while in transit, and (4) the failure of the wind in modern times, active as it is, so to deliver pumice to the caves.

Instead, the exceptional thickness of the pumice in the caves probably is to be explained as primarily a gravity and not an eolian effect. Very likely as the pumice sand fell on the steep hillside above the caves, it tumbled, rolled, or slid down the slope like hail from a roof and accumulated on a shelf at the cave mouths, whence tramping or minor wind action easily could spread it within the wide but shallow caves. Thus a secondary origin of the pumice layer is unnecessary, if not impossible, and an estimate of 12,000 to 14,000 years for the age of the underlying artifacts appears to be justified by the record of the pumice fall in pluvial Winter Lake.

Conclusion

In both the Fort Rock and the Summer Lake basins the general history of the pluvial lakes, parallel to that of Lake Bonneville and Lake Lahontan, and the sedimentary record in such lakes of a series of pumice falls afford a means of dating the volcanic eruptions. Inasmuch as evidences of Early Man in both areas occur beneath layers of air-laid pumice in caves eroded by waves on the shores of large, deep lakes that formerly occupied these basins in Pluvial time, man must have been present in the region before the explosive eruptions both of Mount Mazama (just prior to the formation of the caldera of Crater Lake) and of Newberry Volcano, which supplied the pumice. Judged by the depths of the shrinking pluvial lakes into which the pumice fell, the main Mount Mazama pumice is about 12,000 to 14,000 years old, and that of Newberry Crater about 11,000 or 12,000 years old. These figures in turn represent minimum estimates of man's antiquity in Oregon.

THE NATION'S MILITARY SECURITY

By Captain MYRON W. CURZON, GSC

President Truman's message to the Joint Session of Congress on October 23, 1945, on universal military training clarified a major issue upon which the country must now make a decision. It will be a vital decision. The President's introductory words dealt with "a long range program of national military security." We must inaugurate military policies which will secure our present advantage which prompted General Marshall to report to the Secretary of War that "for the first time [in] . . . six years . . . the security of the United States of America is entirely in our own hands." We cannot gamble with our national existence; the stakes are too big.

Articles which have previously appeared in The Scientific Monthly on universal military training have dealt at length with collateral benefits and detriments which have in the past characterized military service. They have debated the merits of a year of military training—from the standpoint of mental processes, health benefits, and experiences in democracy. These factors are not to be ignored, but the justification for universal military training, conducted by the Army and Navy in military installations and under military regulations, can only be military necessity.

Hopeful though we all are that the United Nations Organization will bring to the world an enduring peace, it is recognized that our obligations under the United Nations Charter requires us to keep ourselves militarily powerful. Other nations will judge the sincerity of our pledges by the manner in which we show ourselves as ready and willing to contribute our share to the enforcement of the Organization's authority. As one key member of the organization we share responsibility for assuming the initiative; other member nations will work with us and gradually the framework of the United Nations Organization, drafted at San Francisco, will take on substance and strength.

Indeed, in our present world where so many nations have learned no other language except that of military power, the voice we raise for peace and international accord must be accented by our own proved ability to support our words with deeds, if necessary, or it will go unheeded at the time it should be heard. Only after the passing of many years and the application of tests not yet devised will we be able to entrust our national security to the stewardship of other powers, no matter in what combination. Today we are faced with the reality that the surest guarantee that no nation will dare again to attack us is to remain strong in the only kind of strength an aggressor understands—military power.

Military Lessons from World Wars I and II. The mobilization of American forces proved to be the decisive factor in winning victory for the Allied Powers in World War I. Hitler and his General Staff absorbed that lesson well; they sought to avoid direct conflict with the United States as they went about their conquests on the European Continent. The available evidence indicates that the Japanese attack at Pearl Harbor was not in accordance with a unified strategic Axis plan. Once the United States was involved, however, forces were set in motion which eventually led to the defeat of these criminal nations—although at a cost even now only partially realized.

Thus, two efforts to achieve world

domination through the conquest of democratic nations failed—one because the aggressor underestimated the effectiveness of American power, the other because the aggressors failed to isolate and immobilize that power. A future aggressor embarking upon world conquest will not commit these mistakes again. The United States, the Arsenal of Democracy in two wars, will be the first target of attack. Not again will we have years in which to prepare to assume the offensive while valiant allies and our own advance guards hold the line. The initial attack, if it comes, will be upon the very heart of the United States. The robot bomb, the rocket, aircraft carriers, and modern air-borne armies have weakened our geographical security.

It is clear that the United States, now possessed of a fighting strength greater than at any time in its history, and greater than that of any other nation in the world, must take direct, positive action to preserve its position.

Our Military Requirements. Our military requirements in the future will be for a force which can be committed to combat in sufficient strength to withstand a surprise attack and undertake a counteroffensive which would overwhelm the enemy. The development of electronic and rocket weapons and the advent of nuclear physics in warfare have not decreased the importance of trained manpower. On the contrary, the day has long since passed when we can call untrained minutemen to the colors in an emergency to oppose with familiar muskets the threat of invasion. We need men versed in the complexities of radar and rockets, airplanes and atomic bombs, amphibious landings and air-borne invasions. It is not the purpose of universal military training to prepare men for wars of the past but to educate our reserves in the intricacies of the type of warfare in which inevitably our total manpower would be engaged if war should come again.

One means of achieving the desired military strength would be to raise and support a large standing Army. We are well aware, however, that the experiences of other nations with large standing armies have been anything but desirable. Exclusive professional soldier castes have developed. Desirable strengths have had to be maintained through resort to conscription. So great a proportion of the national income has been channeled to the military that the nations approached national bankruptcy, from which they were "saved" only by acts of aggression which eventually culminated in war.

The President's proposal that the postwar military organization be composed of—

(1) a comparatively small Regular Army, Navy, and Marine Corps;

(2) a greatly strengthened National Guard and Organized Reserve for the Army, Navy, and Marine Corps; and

(3) a General Reserve composed of all the male citizens of the United States who have received universal military training

successfully avoids the pitfalls of militarism and is a far-reaching step toward the goal of national security. It contemplates a force of regulars, no larger than necessary to perform its normal peacetime duties and to meet sudden minor emergencies, to be reinforced when necessary by reserve forces organized from the trained young men of the Nation.

If these young men are to reinforce our small regular forces promptly for active service in any part of the world, they must be reservists in fact. Otherwise they will require more training upon mobilization and delay the reinforcement of the regular forces, thereby entailing, to provide the same degree of security, a larger and more expensive regular peace establishment than would be necessary if immediately effective reservists were available.

A military organization adapted to the international situation which confronts

us, erected upon our traditional military policy whereby the military is always subordinated to the civilian authority, will be practicable if supported by a system of universal military training, but not otherwise. With it, even with a relatively small establishment, the United States will always have enough organized units in the Regular Army and Navy, the National Guard, and the Organized Reserves to supply a substantial quota in any force required by the United Nations to suppress aggression. To meet a great emergency additional trained reservists will be drawn into the service under such emergency legislation as Congress may enact.

Universal military training is only one of the essential parts of the program of national security for the United States. Equally important are the development of an efficient and practicable scheme for industrial mobilization and an adequate program of scientific research and development. The development of expeditious methods for the mass production of war matériel is an important phase of scientific research which has been neglected in the past.

The adoption of a sound plan for universal military training now will give impetus to the whole program of national security for the United States. The training program will pick up where the military service of the veterans of this war leaves off. Training installations, matériel, and the guidance of combat veterans, with their war lore, uninterrupted and fresh in mind, will be available and at hand. Once we disband and scatter this setup, it will be more difficult and more expensive to re-establish the necessary facilities.

It has been suggested in some quarters that inauguration of the training program should be postponed until the shape of the peace is better known and until our commitments under the United Nations Organization are determined. It is difficult at any time to know precisely what our responsibilities will require in the way of military power. This much we know—if we are to have available a force when needed, the time to begin preparing is now. If, at some later time, conditions change, then the program can be re-examined and revalued.

It is no valid argument against adopting universal military training at this time that there are now millions of trained veterans of this war available for service in any emergency. We cannot rely indefinitely upon those veterans; they have earned the right to return to civil life. In any emergency the burden will rest upon the youth of the nation to constitute the new reserve military strength. If that be their responsibility, then ours is to give them the training to fit them to their tasks.

The Training Program. Both the Army and the Navy have prepared programs for the training of our vast citizen forces. The objectives of the programs are similar—to produce units capable of engaging in combat upon the shortest possible notice. It is no accident that each service recommends that the overall length of the training program be one continuous year. The recommendations are based upon experiences gained under the stress of war, when every nerve and fiber were strained to expedite the flow of men from induction stations to the theater of combat.

A youth will commence his training at the age of eighteen, or upon his graduation from high school—whichever is later; but in any event before his twentieth birthday. Those who complete high school in the seventeenth year may enter upon the training immediately, if they have parental consent. In general, the time at which a youth graduates from high school is optimum from the point of view of his being physically able to undergo the training, mentally capable

of assimilating its principles, and economically able to withstand its interruption to his career. At that time, too, the economic loss in the production of goods and services for the Nation as a whole will be at its least.

Perhaps it is inaccurate to speak of an "interruption" in the young man's life. For the small percentage who might be continuing their education (less than 17 percent of the whole) the year would, as Dr. Karl T. Compton has said, bring the young men to college "with greater maturity, more realistic social adjustment, and greater determination to make the best use of their future educational opportunities." For the rest they would at the conclusion of their training enter the ranks of business, agriculture, or industry with a useful preparation in technical skills and the inculcation of valuable habits of discipline, teamwork, and industry. The year would be a part of, and not apart from, the total educational experience of our youth.

Adequate basic or "boot" training, further technical training applied according to each youth's aptitude and preference insofar as the needs of the services allow, and then unit training culminating in combined maneuvers in which all arms and services participate under simulated battle conditions will provide a well-rounded fifty-two weeks of stimulating activity. The emphasis in the training will not be on mere drilling. It will be on the use of all the instruments and weapons of modern warfare. Every qualified youth will be offered a chance to perfect himself in some military specialty.

Provision will be made within the armed service to help trainees improve their educational status. Ample opportunity will be presented for self-improvement. Some part of the training could be used to develop skills which would be useful in future civilian life. Moral and spiritual guidance has always been considered of highest importance by the armed forces; it will continue so in the training program. Ample medical care will be available.

These programs differ greatly in concept from the three- and four-month replacement training programs of World War II. In the early days of the war well over a year was devoted to the preparation of, first, the individual; then the small unit; and finally the larger unit. After all the units required by the troop basis were trained and transported to the various theaters of operation, the wartime training programs concentrated principally upon providing adequately trained individuals for replacements. The replacement must be trained well as an individual, but since he joins a veteran organization in which he is surrounded with skilled, tried men who willingly aid him, his training need not be as extensive as that of the original members of the group.

Once the youths have completed the prescribed course of training, they would be enrolled in the General Reserve for a period of six years. The General Reserve would be available for rapid mobilization in time of emergency, but no obligation to serve in the military forces would be imposed upon its members, either in this country or abroad, unless and until called by an act of Congress.

Trainees need not stop with the prescribed program. Commissions would be granted to qualified men who complete the course of training and who then take additional instruction in Officer Candidate Schools, in the Reserve Officers Training Corps, and in the Naval Reserve Officers Training Corps. Outstanding trainees could be selected after an adequate period of training and sent to college with Government financial aid, on condition that they return, after graduation and with ROTC training, as junior officers for a year or more of additional training and service.

Freed of the necessity of providing basic training for enrollees, the ROTC program could be established at a high level, comparable to the academic levels of college education in which the young men of the ROTC are engaged. They would be prepared for training as officers, prospective leaders of men. The product of such an ROTC would provide the National Guard and the Organized Reserve with an officer corps of exceptional character.

One continuous year of training will effect the maximum economy in the cost, in time and money, of a universal military-training program. A year of training will not, of course, furnish fully trained men for all the specialties and ratings which the armed forces require. Many specialists require considerably more than a year of training. The numbers of men of this type required for a well-rounded reserve will be met with trainees who volunteer for additional training.

The Role of the Armed Forces. The system of military organization herein described would provide a democratic and efficient military force. It would be a constant bulwark in support of American ideals of government. It would constitute the backbone of defense against any possible future act of aggression.

It has been suggested that universal military training violates traditional American concepts of liberty and democracy and that it will create a militaristic nation. On the contrary, the objective of the program is to train citizens so that, if and when Congress declares it necessary for them to become soldiers, they could do so more quickly and more efficiently. A large trained reserve of peace-loving citizens would never go to war, if it could be avoided. But if war came to them, repetitions of many of the bloody sacrifices heretofore experienced could be rendered unnecessary.

Nothing can alter our Nation's unshakable opposition to war and traditional determination to preserve the peace. We have tried throughout our history to support our pacific purposes with a display of weakness. The inevitable result has been to encourage the vaulting ambitions of every sawdust Caesar who dreamed of world domination. Against their rising power we could oppose only the pitiful weapons of pacts and appeasement. The end of this road was war and war for which we were forever unprepared. The lesson of this our past history is plain. We must enforce our will for peace with military power.

In the words of the former Chief of Staff, General Marshall: "If this nation is to remain great it must bear in mind now and in the future that war is not the choice of those who wish passionately for peace. It is the choice of those who are willing to resort to violence for political advantage. We can fortify ourselves against disaster, I am convinced, by the measures I have here outlined. In these protections we can face the future with a reasonable hope for the best and with quiet assurance that even though the worst may come, we are prepared."

WHAT IS NATIONAL DEFENSE?*

By Lieutenant (jg) KENNETH B. PLATT, USNR

WERE the best course to pursue for our national defense clearly definable, doubtless it would have been so defined long ago. Since the course is uncertain and the problem urgent, thorough exploration of all views is in order.

In his article *The Fallacy of the Lost Year* in the August, 1945, SCIENTIFIC MONTHLY, sounding the virtues of compulsory military training both for its own sake and to improve our educational program, Professor Keller has raised issues too vital to our national future to be left unchallenged. Emphatically, I wish to second his statement: "The proper order of education, especially at the outset of schooling . . . is: obedience first, reasoning second. That has been the order which the race has had to follow if it was to survive. It is the order of learning anything." Unquestionably, our prevailing educational practices would benefit from the introduction of more directed study and the deletion of much folderol. But that a year thus gained would be beneficially spent in compulsory military training as outlined by Professor Keller I feel is a fallacy even greater than the one he decries.

The chief concern of this article is with the problem of national defense. On the educational issue, suffice it to say that the vast amount of new material on the natural sciences brought forward in the past two decades, plus the monumental problems in social science affecting interracial and international relations now crying for the major effort of generations, might well absorb all the educational time salvageable from school activities of questionable value.

What is national-defense preparedness? Before attempting positive suggestions, let us review, through the medium of Professor Keller's article, some of the things which preparedness is *not* and explore the reasons therefor.

1. The basic assumption of Professor Keller, that a large body of trained reserves *is* national-defense preparedness, is the very trap from which the world has just dragged its mangled form. In World War II our backlog of ROTC-trained men accumulated since World War I was entirely ignored except where this training had led to reserve commissions. The swift advance of war methods and equipment had left those men who were trained only basically no better fitted for either leadership or combat than those with no training at all. This experience was paralleled in every other country which had pursued a similar preparedness program. It would doubtless be repeated in the event of a third world war.

World War II demonstrated nothing more clearly than the pitiful inadequacy of orthodox military defense against a determined aggressor. Recent testimony by General Halder, one-time German army chief of staff, showed that Czechoslovakia had 45 divisions of men better trained and equipped than the 15 divisions Hitler had at the time of the Munich *putsch*, plus a more formidable defense cordon than the French Maginot line. Add to this the fact that the Czechoslovak Nation was created by the Allies after World War I specifically to block possible future German ambitions in that direction and was, accordingly, backed by the Allies as one of their prime

* The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or as reflecting the views of the Navy Department or the naval service at large.

defense agents. Yet by one colossal bluff of aggression Hitler negated this whole defense structure, and in the time gained thereby went on to prepare the actual aggressions which demolished Poland and France, each with larger "trained" forces than Germany's, as well as the many smaller countries with armies aggregating far more than the armies of Germany.

In short, this war may be said to have demonstrated incontrovertibly that no nation is prepared to defend itself until it is prepared, psychologically as well as with men and mechanisms, *to wage aggressive offensive war.* This is no startling new idea, but merely a reverse statement of the historic fact that no war ever has been won by defensive means.

Presumably Professor Keller's article already was in print before the atomic bomb burst upon the world, finally and irretrievably shattering the dream of adequate national defense through large standing armies and trained reserves. Actually, this dream has been only a dream, at least ever since science got into full stride. For while it is true that every war has been won by men fighting and dying in battle, it is also true, and decisive, that the means of victory increasingly have come to be the products of superior science. This fact was borne out in a recent tabulation of "lessons learned" in this war, which included as one lesson: "The American soldier learned at Cassarine Pass that he is no better, man for man, than any other soldier with equal equipment and training." The significance of this point as it affects preparedness is that the equipment used at Cassarine Pass was the product of decades of research and development in all branches of science, whereas the G.I. training required to use that equipment to a victorious conclusion was a matter of weeks. Whatever doubt of the futility of numbers of men against superior science may have lingered until Hiroshima and Nagasaki surely has vanished since those doomsdays, as witness the statements of General MacArthur and other eminent militarists that the day of large standing armies is past.

Despite these lessons of current experience, if the United States should now launch into a permanent program of compulsory military training for all physically fit males as they come to military age, there is a very great danger that we should in time come to regard this program as the essence of preparedness.

2. In an early paragraph of his article Professor Keller declares that the youth will benefit from the proposed training in that "his physical defects are going to be detected and rectified, . . . his intoxicants limited, . . . his mental and moral hygiene . . . improved." The experience of the medical profession has been that the majority of physical deficiencies which render a man unfit for military service cannot be satisfactorily cured after the individual reaches military age. It is generally agreed that preventive medicine and hygiene through childhood give the only satisfactory solution to this problem. The fact that most of these deficiencies are regarded as preventable is prima-facie evidence that they should be prevented—by such changes or improvements in our national food, social and recreational habits, sports, hygiene, medical programs, etc., as may be necessary — rather than "cured" after serious harm has been done.

3. Although limiting of intoxicants is a good thing while it lasts, the fallacy of this argument in connection with military training is that the associations and conditions of military life are such as to expand the drinking habit. Coming into this life at an impressionable age, many young men who never before have used intoxicants soon acquire the habit because it is one of the things that "every-

body" does. It is part of the military tradition. Others increase their use of intoxicants out of sheer boredom because bars and saloons often are the only places they can go to mingle with other people during the brief, infrequent, and predominantly night-houred liberty periods customarily granted from military duty. Few will argue that the drinking habit, once acquired, is easily curtailed under self-discipline after imposed prohibitions are removed.

4. The idea of improving the average young American's mental and moral hygiene under conditions of military life simply does not square with the facts. Ask any experienced chaplain. Every circumstance of this unnatural environment is against such improvement. The individual is away from home, family, friends, church, community—away from every outside influence which formerly guided him in a normal balanced life. He is cast into a mass of strange humanity under conditions which, compared with home life, are harsh, confusing, and discouraging. The result is moral corrosion. Although myself raised and hardened in rough company, I found as a Naval enlisted man in "boot" training that masses of men confined in barracks soon dropped to depths of immorality never approached in my previous experience. To quote Kipling (as does Professor Keller, differently) from his immortal character Tommy Atkins:

> An' if some times our conduck isn't all your fancy paints,
> Why, single men in barricks don't grow into plaster saints.

I may add from personal observation that married men react the same as single men in this respect.

5. In a later paragraph Professor Keller surmises we "can be confident that two vitally essential desirables will be inculcated, directly or indirectly, in all curricula: Discipline and 'Democracy'." The fundamental incompatibility of military discipline and democracy was clearly expounded by John Paul Jones[1] in a letter of September 14, 1775, to Joseph Hewes, member of the Marine Committee of the Continental Congress, embodying suggestions on the organization of a naval force, quoted by Buell in his book *Paul Jones,* in part as follows:

> A navy is essentially and necessarily aristocratic. True as may be the political principles for which we are now contending, they can never be practically applied or even admitted on board ship, out of port or off soundings. This may seem a hardship, but it is nevertheless the simplest of truths. Whilst the ships sent forth by the Congress may and must fight for the principles of human rights and republican freedom, the ships themselves must be ruled and commanded at sea under a system of absolute despotism.

The same relationship between commanders and commanded might have been as well bespoken for army organization. The years have altered this relationship little, if any. Certainly they have not altered the professional militarists' view on the subject. Despite much talk of a "democratic" army in this war, it just did not work out. It could not. We will do ourselves a service if we recognize at the outset that military discipline is part and parcel of military method, and that it is applied from above, inevitably. At the same time every effort should be made to encourage self-discipline in everyday life as one of the priceless fundamentals of true leadership ability which gave us a decisive edge over the discipline-numbed German soldier of World War I, who was helpless when his officers were put out of action. Where we *must* have superimposed discipline, so be it; but let us not fool ourselves that it is good for its own sake.

[1] The authenticity of this letter has been denied by DeKoven (*Life and Letters of John Paul Jones*), but its wide acceptance and teaching as the "moral and intellectual charter of Annapolis" make that point irrelevant to the present argument.

6. As for the prospects of discipline in the proposed compulsory military training program, I do not share Professor Keller's confidence that "it is not at all likely" that the military establishment will impose "a narrow type of it" as in the past, nor that "if it should run in a lot of duds or dubs, in courses or teachers, they will be speedily shown up." Unfortunately in this regard, military discipline requires unquestioning obedience and universal conformity. Unfortunately, too, for the outlook of the prospective trainee, the lower one goes in the military hierarchy the more does force of rank depend upon autocratic authority rather than upon leadership stature. In the final analysis the private in the ranks is left with no recourse except unprotesting subservience to the lowest bracket of officers. Assuming that the trainee will be under permanent organization personnel for the most part, I cannot but feel dubious of his benefits from these discipline contacts, for the obvious reason that men of strong leadership ability do not commonly fall into life careers as noncommissioned military officers. And should the misfit courses and teachers be "shown up" as Professor Keller assumes, by no means does it follow that they would be removed. Indeed, if one may judge by the degrees of incompetence tolerated by the inertia of the military machine in other parts of its mechanism even under war urgency, the probabilities of speedy adjustment of training schedules and personnel under a permanent peacetime training program seem remote.

"Intelligent discipline" is specified in Professor Keller's argument. Yet one may validly question whether there is, or can be, such a thing as intelligent discipline superimposed upon any large mass of adult or near-adult persons with heterogeneous backgrounds and abilities. Visit any large municipal court—an everyday laboratory of applied mass discipline—and you will find that the intelligence factor in the law is injected through *variations* in its application to fit the circumstances and the individual, rather than through rigidity. That the casting of all minds in one mold is not intelligent education long has been recognized. True, the swing toward unguided learning has gone too far in many cases, and educators now are returning to a greater degree of standardization in education as necessary to fit oncoming generations to the realities of our social structure. But it will be agreed, I think, that this standardization should be held to the minimum conformable with social necessity. Likewise, I feel it will be agreed that superimposed discipline as a principle in any part of our lives should be used only as necessity demands.

Recognizing the whole institution of militarism as a social aberration in a world not yet matured to international self-discipline, let us then recognize military discipline for what it is—a necessary ingredient of the military method, whose application we should seek to reduce as rapidly as conditions warrant.

Some Suggestions For Our National Defense. The impossiblity of stabilized military security in a war-minded world is easily demonstrable to any logical mind, since one nation's security automatically spells insecurity for all other nations against which that security is calculated. This article assumes that our first and greatest effort should be toward prevention of international friction as the only solid ground for international peace. But well-intentioned peace efforts have failed in the past and may fail again. So great is this risk that we are compelled to consider every means by which we may resist aggression.

The secret of America's strength in battle has had as many explanations as Sampson's: Our great manpower; our individual superiority, man for man; our

vast natural resources; our unrivaled industrial advancement; our immunity from attack; our unmatched inventiveness; our unity of purpose; and so on. Yet in each of these elements we have been equaled or surpassed by other nations. The real secret of our strength, the catalytic agent that has activated all the separate elements into an invincible combination, is the unfettered American mind.

In World War I we beat the German military machine, the perfection of generations of military planning, training, and preparation, by virtue of our freedom from the rigidity imposed by such a preparatory program. Because we were not bound to a preconceived pattern, we could create a more effective pattern. In World War II we beat the Axis military machine because the unfettered American mind outstripped the driven Axis mind in producing new and more effective engines of war. Our advantage in each case was merely a different facet of the same gem—greater freedom to think and act on individual initiative. And so long as the minds of men vary in capacity and resource, such freedom will remain an advantage over any conceivable regimented program.

It follows that our best defense against possible future aggressions lies in a course which will enhance this inherent advantage of democracy. Education for life will continue to be more productive of advancement than is education for death. Let us therefore hold fast to our traditions of universal liberal education. But let us broaden this education with a modernized view of social and economic relationships, from backyard to world scope. The emphasis on material production which has characterized our society in recent generations needs now to be shifted to a study of more equitable distribution of the fruits of the machine age. In a society which devotes over 90 percent of its time to its own operation and less than 10 percent of its time to producing the necessities of life, yet continues in devastating internal and international strife over allocation of these necessities, the need for more effort toward perfecting the social organization is evident. And when we recognize the industrial strikes now paralyzing America and Britain as symptoms of the same disease which produces wars, we see that there is plenty to be done here at home in strengthening ourselves against possible outside aggression. Be it not forgotten that it was internal strife rather than lack of military defense which made France so vulnerable to the Nazi blitz.

Upon the foregoing broad background of liberal tradition, universal education, and internal solidarity the following specific suggestions for our national defense are offered:

1. First essential for our future national defense, of course, is a unified defense command other than that now lodged in the President as Commander in Chief of both Army and Navy. Our Presidents are not elected for their military prowess, and even if the public at large could and would choose them on that basis, the other duties of the office would preclude adequate fulfillment of the military function. So widely has this point been argued in recent months that space will not be taken to discuss it here.

2. The pace of science in devising new instruments and techniques of war makes it utterly impractical to keep a large segment of the population adequately up-to-date in their uses. Equally impractical because of its inadequacy and rapid obsolescence is such partial training as might be given in a year of compulsory basic military training. On the other hand, an effective and not unduly costly program for providing the essential corps of thoroughly trained military personnel for defense emergencies would be to expand our West Point and Annapolis programs to several times their present size, at the

same time injecting into these programs such additional materials as might be necessary to turn out graduates fitted for various civilian pursuits closely related to military effort—engineers, chemists, transportation experts, disaster relief experts, public-health doctors, and nurses —to name a few. Let the graduates of this program in excess of the needs of our standing forces be given reserve commissions and required to keep them current with refresher training at suitable periods. Precedent for such a course was established by default during the two decades preceding World War II, when even the limited numbers graduated from our military and naval academies exceeded the needs of our standing forces and many graduates could not be given active commissions. A planned program along this line would seem better preparedness than the default situation, which may be expected to arise again when our armed forces are pared to peacetime needs.

The realities of total war—and any major conflict of the future must be expected to be total war—are such as strongly to commend such an arrangement. In total war total populations and total resources must be mobilized to the cause. This is not readily done by strictly military methods in a society essentially dedicated to peaceful pursuits and traditionally steeped in liberal democratic government. In war the need arises for large numbers of persons familiar with both civilian and military needs and capable of integrating the two with greatest over-all efficiency, for the military machine necessarily is powered by civilian effort. The more complex our society grows the more essential becomes the military-civilian liaison function. For this reason it may well be argued that a deliberate policy of injecting militarily trained personnel into key civilian pursuits in peacetime is essential to any realistic preparedness program. In fact, a strong case could be made for requiring even Army and Navy career men to spend one year in five in a civilian occupation, to keep them acquainted with the realities of the social organization from which their strength must come in case of war.

3. Any preparedness program which fails to include women in large numbers ignores the facts of total war so recently demonstrated to us. Behind-the-lines activities of armed forces more and more can be taken over by women as the use of machines and instruments increases. At no time in this war did our women fill all, or nearly all, the military positions they might have filled equally as well as men. Especially critical was the shortage of nurses. Since nurses cannot be trained quickly, and since future aggressions may be expected to strike without warning and on a very broad scale, the presence throughout the nation of large numbers of trained nurses commends itself as an essential of national-defense preparedness.

4. An adequate peacetime public-health program embodying currently known principles of preventive medicine and personal hygiene could make profitable use of the women so trained. Such a program, fully justifiable for its own sake, must be included among the essentials of national-defense preparedness. Selective Service reports show that for every three men inducted into our armed forces one was rejected for physical, mental, educational, or moral reasons. A very large share of these rejections could have been avoided by a program of preventive medicine, child care, accident prevention, and truly population-wide education applied through the years preceding military age. And another war, more devastating and draining than the last, may not find us with a 25 percent margin of manpower not needed in actual combat.

Much of the needed public-health pro-

gram could and should be accomplished in the schools. The competitive sports which comprise almost the total physical development program of most of our schools are good in themselves when not overdone. But too few students participate in these sports, and too many participants sustain disabling injuries. College sport participation is coming to be the almost exclusive realm of professional athletes, themselves often permanently disabled by too strenuous action. From primary grades through college our physical education program is in need of drastic overhauling. A candid view of our probable future defense requirements calls for thorough hygienic education and bodily development of *all* persons of both sexes not incapacitated by insurmountable deficiencies. The methods for doing this are well known; all that lacks is their proper application.

5. Universal health and strength are not enough. An understanding of world forces is needed both to forestall possible wars and to defend ourselves if attacked. Science has so far outstripped the humanities that we now find ourselves with no dependable approach to the problems in class and international conflict brought on by development of unlimited capacity for production of goods and services. The great need now and for the future is to close this gap between scientific advancement and advancement in human relationships. To this end it it here suggested that our whole educational curriculum be redrafted to direct emphasis upon world problems. There need be no concern for the future of science under such a program, for science may be expected to continue or accelerate its current rate of discovery and invention for a long period to come, without other encouragement than a free hand in research. The real issue is that the products of science are pointless if kept in the laboratory; whereas, once out of the laboratory, they may do far more harm than good if exploited by unscrupulous or unenlightened leaders placed in power by peoples unaware of ultimate results to be expected from current measures and policies. Was not Nazi Germany an example of this outcome? And is not our present industrial paralysis a symptom of the same organic weakness?

Ten years ago Alexis Carrel, in his *Man the Unknown*, suggested that soon significant advancement in our knowledge of man as an organism might require as much as 30 years of intensive preparation by the most able scholars in many related fields of science. Is it too much to suggest that in the field of human relationships, already far behind scientific developments, we could well afford to encourage and direct similar intensive preparation of some of our best minds for devotion to national and world improvement in government, economics, sociology, and religion? Certainly we should take more positive measures than we do now toward intelligent preparation of intelligent men and women for places in public life, especially of those who are to represent us abroad. If internal strength, international prestige, and international goodwill be elements of national security, then added emphasis upon study of the humanities is one of our "musts" of future national defense.

Specifically, the indigestible mixture of statistics, irrelevant chronologies, and romanticized military campaigns now taught as history should be replaced with a realistic summary of man's circuitous "progress" through the various forms of government and social structure, philosophy, religion, material culture, etc., with a deadly earnest effort to interpret the cause-and-effect relationship behind their respective ascendencies, conflicts, and collapses. Geography should be raised from travelogue scope to its rightful stature as a study of natural resources, climates, peoples, and cultures each reacting upon the other to affect

the destiny of nations and the course of history, past and future. The languages of at least half a dozen leading nations besides our own should be widely taught throughout our school structure, and mastery of at least one of them required of every college graduate. World-wide international student exchanges should be encouraged—subsidized if necessary—to the point of assuring greatly improved mutual understanding with all nations.

If such a program requires more years of education, so be it. We can well afford them. Further, it is here proposed that the time has fully come when we should expand our compulsory education requirements to include high-school level. Our forefathers pioneered universal education as one of the fundamentals of sound democracy. Today we are in danger of losing that democracy through the votes of those who leave school without any real understanding of our present society, now vastly more complex than in the days when the three R's were the fundamentals of our culture. Regardless of whether we increase our compulsory education requirements, we should make wide use of newly perfected aptitude screening tests to develop a channeling program for students above grade-school level to assure as far as possible that each will spend his time in a field promising to be profitable both to him and to society.

7. For investigations costly beyond the scope of private and state research institutions, such as the controlled use of atomic energy, where probable national benefit promises to justify the expenditure, federal subsidies should be provided. Much research in aeronautics, electronics, and other war-vital fields also probably will require federal support for rapid progress. That such support should be given where needed is so obvious as to be given only passing mention here. Government controls over the research so supported, however, should be scrupulously limited to reasonable accounting of funds. Direction of the research itself must be left to suitable committees of leading scientific workers.

8. In event of future wars, greater care than heretofore should be given to retaining in their respective fields the largest possible number of scientific workers and students, medical students, skilled technicians, etc. The traditional dictum of our democracy that in time of war all are subject to the battle call, regardless of station, loses its validity when a literal application threatens the ability of the nation to win that battle, or to maintain its ascendency after the battle is won. Careful peacetime studies of the probable war necessity of every branch of science should be made by men qualified to judge. Likewise, ratings may be placed upon individual scientific workers on the basis of intelligence tests, college records, and subsequent work, with a view to determining degrees of dispensability in a war emergency. Similar records might be compiled to cover workers in other essential technical or professional fields requiring long periods of preparation. Consultation of these records in wartime placement of personnel would avoid unnecessary training programs and many costly delays in manning war activities.

SCIENCE ON THE MARCH

NOTES ON THE SOLAR ECLIPSE OF JULY 9, 1945

Reports are still drifting in on the results of the solar eclipse of July 9, 1945. The path of the moon's shadow stretched from Boise, Idaho, through central Canada across Hudson Bay into Greenland, and across the Scandinavian Peninsula into Asia. In spite of war conditions, professional and amateur astronomers stood watch in this country and in Canada along the central line. The eclipse watchers met with various degrees of luck in observing weather. A New York party found clear weather at a station overlooking Basin Creek Valley near Butte, Mont. In the same state at Malta under partly clouded skies, Princeton's Professor John Q. Stewart and General Electric's James Stokley, with others in their group, made 36 photographs of the corona and the moon's shadow during the 30 seconds of totality allotted. Dr. Walter T. Whitney, of Pomona College, was partly successful in spite of threatening clouds at Opheim, Mont. Amateur astronomers reported fair weather at Francis in Saskatchewan, and the astronomers at Wolseley, Saskatchewan, including Dr. Roy K. Marshall, of the Franklin Institute, and Dr. Orren Mohler, of the McMath-Hulbert Observatory, reported perfect visibility following early morning clouds.

An elaborately equipped party under the leadership of Lt. Comdr. Donald H. Menzel reported that clouds prevented a view of any part of the eclipse. Also clouded out were Dr. Charles H. Smiley, of Brown University, and Dr. C. H. Gingrich, of Carleton College. They were located at Roblin, Manitoba, along with Professor C. M. Huffer, of Beloit College, and T. J. Bartlett, of Northwestern. At Pine River a party from the Yerkes Observatory was successful in their long-focus photographs of the eclipsed sun. The corona has been described, by those who were successful in seeing it, as of the sunspot-minimum type with extended streamers emanating from the solar equatorial zone.

Unique among the reported observations were recordings of atmospheric electric effects made at God's Lake, Hudson Bay. J. T. Wilson reports results in the September issue of the Allis-Chalmers *Electrical Review*. In addition to employing photographic and meteorological equipment, special provision was made for observing measurements of the atmospheric potential gradient before, during, and after the eclipse. By means of an electrometer in connection with a collector they reported not only an abrupt change in the potential gradient but also an actual reversal in sign accompanying or shortly following totality. While before totality the potential gradient of the atmosphere registered steadily about 150 volts negative, within 3 minutes after the duration of the total phase the gradient dropped rapidly to 0, reversed in sign and actually attained about 75 volts positive; after which it again returned to the apparently normal pre-eclipse value.

These observations are particularly significant since during many recent eclipses ionospheric observations have shown a marked drop in the ionization of the upper atmosphere, immediately accompanying envelopment in the moon's shadow. These previously well-recognized results have substantiated the belief that the principal ionizing agent for the radio-reflecting layers consists of ultraviolet radiation from the sun. Studies of aurorae by Störmer and others have indicated the existence of electrons or charged corpuscles emanating from the sun as a supplementary source

of ionization in the earth's atmosphere. Search has been made at various eclipses to detect the effect of a corpuscular radiation from the sun on the presumption that such charged particles travel much more slowly than the velocity of light. Results have been conflicting and thus far have failed to prove conclusively that the screening of such radiation by the moon could be detected by radio means.

The results of the observers at God's Lake, therefore, are of much interest, especially since their readings indicated a lag of 3 minutes between totality and the beginning of the fall in the atmospheric potential at the earth's surface. Were this potential, in part, maintained by charged particles emitted from the sun, then this time lag might be interpreted as an index of the velocity of such particles in the earth's atmosphere. On such an assumption one might reason that corpuscles travel at such a velocity as to consume 3 minutes in passing from the moon to the earth, since no change was observed until 3 minutes had elapsed after the moon had effectively screened all radiation of the sun from the shadow cone. On the other hand, if ionization of the lower atmosphere, which is related to conductivity and potential, were to be regarded as a progressive effect from the top of the atmosphere down, then such reasoning would not necessarily hold.

Unfortunately, there are other matters to be considered in interpreting the change observed in atmospheric potential during the eclipse. The weather was in general unfavorable with passing clouds. Since clouds generally carry charges of electricity, one cannot exclude altogether the possibility of their effect in the recorded readings of the electrometer. However, clouds had been passing before totality and no such effects were observed. It seems rather unreasonable to suppose that the effects recorded were due to peculiar cloud formations which occurred just after totality. It is to be noted that nearly 40 minutes elapsed following the eclipse before the atmospheric potential returned to normal. Whatever may be the correct interpretation of the atmospheric electric observations made at God's Lake, new interest has been added to future solar eclipses.

More and more we are impressed with the important part which radiation of the sun plays in maintaining the electrical state of the earth's atmosphere. Every solar eclipse gives opportunity for a study of such changes as may take place under the unique conditions staged by nature when, within the shadow of the moon, all solar radiation is suddenly screened by the interposition of our satellite. It may be noted that coming eclipses will occur during a higher degree of sunspot activity. Such effects as were observed at God's Lake and effects readily observable by radio soundings of the ionosphere may be much accentuated with increasing solar activity.

HARLAN T. STETSON

GERONTOLOGY COMES OF AGE

AGING is as old as time. But gerontology, the science of aging, is very young. Until recently biologists and physicians have been strangely content to take aging as a matter of course. Only poets and philosophers wrote about old age. Scientific interest in aging has been more active about the fringe of this vast and unexplored continent of thought; astronomers have been concerned with calculating the age of the universe, geologists have long worried over the age of the earth, and anthropologists and archeologists have struggled to estimate the age of man as a species. But the aging of men and women as *individuals* has received scant attention until recently, and very little indeed is known anent the basic mechanisms of aging as a biological process.

Man is a utilitarian creature, and few

indeed are those scientists who seek understanding with purely abstract curiosity. Fewer still are those who encourage and finance pure research free of any expectation of practical application. Until recently the problems of aging presented largely academic and theoretical interest. This is now changed. Today there is real urgency in the need to know more, much more, about aging. In the past fifty years preventive medicine, sanitation, and improved therapeutics have raised dramatically the age of our population. This increase in age continues and in fact was accelerated in the past decade.

At the turn of the century the average life expectancy at birth was but 47 years; today it exceeds 63. In 1900 only 17 percent of the total population of the United States were 45 years or more. In 1940, 26.5 percent were over 45, and conservative projection leads us to expect that in 1980—ony 40 years hence, which is not long in the life of a nation, although it may seem long to an individual —more than 40 percent of our people will be over 45. Data from the 1940 census reveal that the population of the United States as a whole increased 7.2 percent since 1930, but that the number of persons aged 65 or more increased 35 percent in this past decade. There are now in this country about 9 million people who are 65 or more. It is predicted that this fraction of our population will more than double in the next forty years.

Obviously, the aged are here; there will be many more of them in the years to come. This older fraction of our population represents an immense but thus far largely unutilized and unappreciated resource. The increasing millions of older men and women will remain an urgent problem and a potential menace to national economic equilibrium until we know enough about aging to maintain health into senility and to use wisely the changed capacities of those past the meridian.

Gerontology, like all Gaul, is divided into three parts. The divisions are intimately and inseparably related, although they involve widely differing disciplines. All living matter ages. Thus the study of aging requires correlated cooperation between the many branches of biological and physical sicences. These interrelationships are pragmatic as well as theoretical; advances in knowledge in any one field depend largely upon parallel or preceding progress in the other categories.

The logical divisions of gerontology are:

(1) The biology of aging.
  Phenomena of evolution or development.
  Phenomena of involution or senescence.
(2) The clinical problems of aging man.
  Pediatrics.
  Geriatrics.
    Normal senescence and senility.
    Diseases of the senescent period.
(3) The socio-economic problems of aging mankind.

Gerontology is growing up. For several years a group of scientists, each busy working in his own field of study and applying highly specialized techniques to some aspect of aging, has felt the need for some medium by which the various observations concerning aging could be correlated and made more meaningful. This small group, meeting annually for the past six years as the Club for Research on Aging, has now extended the scope of its activities by forming the Gerontological Society, Inc., and conceiving the *Journal of Gerontology,* the first issue of which is to appear this month. The Journal will be published by Charles Thomas, Inc., of Springfield, Ill., for the Society.

The *Journal of Gerontology* is more than merely another scientific periodical. It is unique in the breadth of its field, for it will try to present and correlate all

three of the major subdivisions of gerontology. Man is the core of interest. Therefore clinical geriatrics will receive special prominence. But man is composed of myriads of cells functioning in complex harmony. The fundamentals of the biology of senescence form the basis for advances in clinical knowledge and application. Accordingly, the biological sciences are recognized as being highly significant. Similarly, men and women constitute the basic units of collective society or the body politic. Sociology, biology, and medicine constitute the triad of facets. It will be a major function of the *Journal of Gerontology* to correlate these three viewpoints into a unified whole.

The editor-in-chief, Dr. Robert A. Moore, of the Department of Pathology, Washington University, St. Louis, has a herculean task of orchestration before him. However, the first issue of this new journal demonstrates his capacity as conductor. Dr. Moore has obtained the assistance of an extensive and widely recognized group of editorial advisers; consequently no subdivisions of the field will be neglected. A wholly original innovation will be the publication of a nontechnical supplement with each issue. The supplement will contain carefully prepared digests of all the articles in the main journal, written in nontechnical language so that the sociologist may understand the chemist, the anatomist the psychiatrist, or the aged themselves the whole conglomerate orchestra. It will be more than interesting to observe the effectiveness and development of this completely new editorial concept.

The future of gerontology is bright. There is much to be learned about aging and the aged. And we need to learn *now*. Gerontology is now of age. It will continue to mature, as do we all. If its further maturation be wisely guided, mankind will be enabled to make good use of the increased longevity which is already here. Let us not forget that it remains for mature senescents to explore fully and develop all the wondrous potentialities of man himself.

EDWARD J. STIEGLITZ

BOOK REVIEWS

G.I. SNAKES

Reptiles of the Pacific World. Arthur Loveridge. 259 pp. illus. 1945. $3.00. The Macmillan Co., New York.

MR. LOVERIDGE was given a difficult task when he was assigned to cover the reptiles of the Pacific World. The very title gives a hint of the territory covered —from the Galapagos west! It sounds like the charters of our early Colonies. His next hurdle was the time element— the book had to appear in time to be of use to the G.I. overseas. Another handicap—his personal field experience had been in Africa. Add to this that many of his sources of reference were old enough to be almost legendary. Only limited parts of the area had been covered by the reports of herpetologists— great spaces remained to be filled in by study of relatively few museum specimens. Lastly and most important, he was not writing for an audience of herpetologists or even for beginners in herpetology—he had to make the book so interesting that it would recruit followers for herpetology, or for any branch of natural history for that matter.

The result is a great success and it was cleverly accomplished. He uses the inimitable style of Ivan Sanderson, making the best of the exciting size of overlarge crocodiles and snakes and stressing the gruesome data of their liking for human flesh. He uses keys to an extent sufficient to acquaint the beginner with their use without boring him. The plates are clear, well-drawn, and serve as a glossary. He coins the word "scansor," meaning "climber"—a welcome addition to the herpetologist's vocabulary, but his use of "cadaverous" for feeding on corpses is too much of an innovation. Had he coined "cadavorous" it might have passed in lieu of "necrophagus," the word usually employed to express his meaning.

The body of the book first acquaints us with how reptiles arrived on these isolated specks of land. Some of us may not visualize Galapagos tortoises "floating" from one island to another, but like the man who was contradicted when he stated that in his country buffaloes climbed trees, his challenger had to admit that he had never seen one try. He makes clear what is meant by the word "reptile." In sequence he takes up turtles, crocodiles, lizards and snakes. These are treated so that anyone having read the book will have a good idea of at least what genus he is looking at or where to look it up. Among the closing chapters he treats of snake bite in such a manner as to remove the hysteria and inject common sense. Having abated the unnecessary fear of poison, he logically takes up the beneficial aspect of reptiles as destroyers of vermin.

The title of the book does not include Amphibia, but Mr. Loveridge gratuitously inserts an interesting survey of that subject so that the reader obtains a good idea of the amphibia he may meet in the Pacific World.

Throughout the book he mentions localities in which to search for species desired by museums. The last chapter treats of the methods for collecting, preserving, and shipping specimens to museums. The theme of being able to kill and at the same time advance science appeals to a G.I. as well as to a big game hunter.

A distribution chart is valuable as a preliminary check in that it eliminates and reduces possibilities for identification. A very good selection of works on oriental herpetology published in English is appended for those who may wish to pursue the study.

The book closes with what is called an "Index to, and a systematic list of, species mentioned." This is really not an

index since it is not alphabetically arranged, but a table of contents of chapters 3 to 9 inclusive inserted at the back of the book. It takes the place of an index for a person familiar with the book.

A small but unabridged edition was published in handbook form for distribution to the Armed Services. The Editor of the *Infantry Journal* writes me: "Several hundred thousand of the Pacific Series have been printed and most of these have been distributed to the Armed Forces." Thus Mr. Loveridge's book probably has had the greatest distribution of any book ever written on herpetology.

CHAPMAN GRANT

THE USE OF PSYCHOLOGY AND PSYCHIATRY IN WAR

Psychology for the Armed Services. Edited by Edwin G. Boring. 533 pp. Illus. 1945. $3.00. The Infantry Journal. Washington, D. C.

PSYCHOLOGY, like other sciences, has many uses in war. That statement appears so obvious it should be hardly necessary to labor the point. Even a superficial survey would reveal plentiful evidence of psychology's contribution towards the solution of countless military problems. Yet, there is great need for a well-organized presentation of the application of psychological principles to war situations. Necessarily, a book attempting to cover the subject should address itself to military and naval personnel generally, and to leaders of men in the armed forces especially. For while it is almost self-evident to psychologists that the possible ways in which the science can be applied are numerous, experience in two World Wars has shown that military leaders are unconvinced or unenlightened in that respect. There is therefore a definite need for a lucid enumeration and thorough discussion of the uses of psychology in wartime.

Towards the fulfillment of that need, this book was prepared by a Subcommittee of the National Research Council. The members of the Subcommittee and the contributors to various sections of the book comprise a body of outstanding experts in psychology. With few exceptions, the text is aptly illustrated. Diagrams, tables, and charts are ample and well-planned. A select list of references follows each chapter. The result is a handy, well-written textbook nicely suited to the college level.

The subjects, for the most part, are treated in a practical manner. The physiology of the sense organs is summarized and illustrated. The applications to military situations are enumerated in discussions of night vision, camouflage, war gases, efficiency, and fatigue. Certain topics, on the other hand, are handled with kid gloves. It seems as though here and there a punch is being pulled. This is especially noticeable in the treatment of the problem of fraternization with enemy peoples. The discussion sounds very much like an Army directive recast in psychological terminology. Here one feels that psychology has made no real contribution but has been content to follow established military policy. Sometimes topics are introduced in a roundabout and pointlessly involved fashion. For example, the subject of leadership is approached by a discussion of hypnosis. According to the author, the relationship between hypnotist and subject is an "extreme leadership relation." That is a highly debatable question. Certainly the argument presented for it seems forced. At any rate, the leadership attributes listed bear little or no relationship to what might be the attributes of the hypnotist, which in turn will depend on the theory of hypnotism one supports. Despite such occasional lapses, we can agree with the prefatory claim that this isn't simply a war book,

but a work of broad and continuing military usefulness. It should prove of value to men in positions of responsibility and leadership in all the services. It can be recommended for use in military or naval academies. Projects of this nature are necessary steps in attaining the goal of a military leadership intelligently aware of the most effective and appropriate utilizations of psychological services.

Psychiatry in Modern Warfare. Edward A. Strecker and Kenneth E. Appel. 88 pp. 1945. $1.50. The Macmillan Company, New York.

In the first World War, one out of every seven battle casualties was neuropsychiatric; in World War II, the proportion is one out of three, or about thirty percent. The increased frequency, therefore, poses a problem of paramount concern to military authorities, psychiatrists, and educators. Adequate discussion of the problem necessitates an examination of the nature of warfare in the two World Wars and evaluation of the psychological consequences of warfare. Also necessary, or at least desirable, would be a comparison between the two wars as regards the organization of military psychiatry, diagnostic and therapeutic procedures, and the incidence of psychiatric conditions in each war. The authors have combined their intimate knowledge of military psychiatric practices to present, in this brief treatise, an admirable study of psychiatry in the two wars which more than meets the minimum requirements for handling satisfactorily a subject of such scope. Part I contrasts the nature of warfare in World Wars I and II and considers the psychological effects on combatants and noncombatants. It appraises the record of psychiatry in each war with reference to organization, statistics, etiology, symptomatology, psychopathology, treatment, prognosis, and incidence. The second half of this concisely written survey discusses the more important readjustment problems facing the returning veteran. Under the general heading of Demobilization are considered such aspects as the need for readjustment among civilians and veterans alike, special difficulties confronting the veteran, concrete measures designed to help in the process, and an enumeration of the suggested improvements in facilities for veterans. This second part is a more popular presentation of the general subject.

Such concentrated treatment of a complex subject, as the study accomplishes so well, is bound to skip some phases or suggest them only by implication. Thus, the authors state, "It is interesting to speculate as to why conversion hysteria is relatively infrequent in World War II as compared with World War I, and why anxiety reactions have so frequently replaced it." The speculations that follow explain the incidence of anxiety reactions in World War II without discussing the greater incidence of conversion hysteria in World War I. The anxiety reactions are ascribed to "increased stimulation, alertness, . . . tension of the organism; . . . lessened security, increased fear." These are the psychological consequences of global warfare. Apparently, there is a tendency to ignore the possibility that these psychological effects occupied parallel roles for the soldiers of World Wars I and II. In fact, these factors may be psychologically parallel for the combatants of all wars. Why, then, was conversion hysteria more frequent than anxiety reactions in World War I? Have diagnostic criteria undergone some subtle modifications which might account for the difference? These aspects of the problem have not been covered.

However, the positive merits of the study are so many, that any final evaluation must judge it to represent one of

the most helpful sources of reference pertaining to the record of neuropsychiatry in the two world wars. Few readers will fail to find much of practical interest in this handy survey. All, undoubtedly, will gain the impression of having been given a rich and comprehensive insight into the problem of neuropsychiatric battle casualties.

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CATALYSTS IN ACTION

Catalytic Chemistry. Henry William Lohse. 471 pp. Illus. $8.50. Chemical Publishing Co., Inc. Brooklyn.

PRODUCERS of desirable substances from the time of the alchemists, who sought the philosopher's stone, to modern man's endeavor to attain artificial photosynthesis have continued to search for accelerators of production.

The number of workers in this field of research is becoming so great and the published results of their achievements are so voluminous that it becomes almost imperative that from time to time some worker in the field pause long enough to make a survey of findings and abstract them for himself and others. Such a service the author of the book under review has performed. His author index of over 1000 names and footnote references in equal or greater numbers testify to the magnitude of his labors.

His program of presentation is in five chapters entitled: Brief History, Catalytic Theory, Nature and Properties of Catalysts, Specific Types of Catalytic Reactions, and finally Industrial Catalytic Reactions. In the second chapter he groups the theories under the captions of those that have to do with homogeneous and those that have to do with heterogeneous reactions. The subdivisions under the first include: chain reactions, vapor and gas reactions, liquid phase reactions, acid-base catalysts, salt, and solvent effects, hydrolytic and finally intermolecular changes. Under the heterogeneous grouping are: phases, adsorption, desorption, activity, selectivity, surface specificity, activation energy, heterogeneous chain and wall reactions.

The nature and properties of catalysts are systematically treated for the elements and compounds in their relation to their classification in the eight groups of the Moseley-Mendeleff periodic chart.

The specific types of catalytic reactions are listed in chapter four as: oxidation, dehydrogenation, cyclization, hydrogenation, hydration, hydrolysis, dehydration, esterification, halogenation, alkylation, isomerization, condensation, polymerization, sulfonation, desulfurization, amination, ammonolysis, enzymes and organic catalysts.

Obviously not all catalytic reactions of industrial interest can be included in a one-volume digest. Those considered of major concern, by the author, are: the industries of nitrogen fixation; those stemming from acetylene derivatives; industry related to carbon oxides and "water gas," industrial alcohol, hydrocarbon cracking and coal hydrogenation, synthetic rubber, processing vegetable and animal fats including dehydration and hydrolysis of oils and fats.

Aside from a brief nine-page gesture toward enzymes and organic catalysts the volume could be considered as exclusively concerned with inorganic catalysts. However, a strict reminder should be voiced that a major number of the present uses of catalysts is in the field of organic syntheses. Dr. Lohse might, with propriety, have alluded in his preface to the growing use of organic and enzyme catalysts in the industrial field as well as in natural biochemical processes. Is it in order to suggest the need of a volume devoted to progress in that phase of catalysis as a companion to the one under review?

The reviewer is quite convinced that

an interested student or investigator will not find elsewhere so much, in so brief a span, devoted to the field of catalysis. It is highly gratifying to find an adequate thirty-four page subject index as a part of its offering. It is regrettable, however, that so desirable a working tool should be kept away from the work tables of everyone interested in catalysis by a price which is about double what it should be.

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MAN—HIS SUCCESSES AND FAILURES

Modern Man is Obsolete. Norman Cousins. 59 pp. 1945. $3.00. The Macmillan Company, New York.

Between Two Wars: The Failure of Education, 1920–1940. Porter Sargent. 608 pp. 1945. $5.00. Porter Sargent, Boston, Mass.

A State University Surveys the Humanities. Edited by Loren C. McKinney, Nicholson B. Adams, and Harry K. Russell. 365 pp. 1945. $4.00. The University of North Carolina Press, Chapel Hill.

THESE three volumes emphasize the urgency of adapting designs of social living to scientific fact.

Modern man is obsolete, says Cousins. By surrounding and confounding himself with gaps between "revolutionary technology and evolutionary man, between cosmic gadgets and human wisdom, between intellect and conscience, he has made himself an anachronism." To span the gap man must become cooperative instead of viciously competitive, must develop critical intelligence, and establish a common world sovereignty expressed through world government. What the world needs, when time no longer works for peace, is not another conference but a Constitutional Convention to organize man's social institutions to meet the range and tempo of scientific achievements.

Between Two Wars is a typical "Sargentesque" manifesto to educators to "maintain conscience against the insiduous conditioning to our atavistic ideas of sovereignty." It is a declaration of freedom from "fixed traditional practices" which condition each new generation to make "good citizens" by blind loyalty to those in authority. Sargent wants teachers who can "start the pupils' internal combustion engine without the present-day sputtering and backfiring." He wants students to discover their own self-starter and "freed from the chains dragging from the past, with fluid drive, with clearly seen objectives ahead," . . . to "take to the road onward and upward." With the exception of the concluding chapter the volume is a reprint of Sargent's annual prefaces in *The Handbook of Private Schools.*

One of a series of volumes by divisional faculties to appraise the condition of the University of North Carolina on the occasion of its 150th anniversary, *A State University Surveys the Humanities* presents essays outlining what some professors understand by the leavening influence of the humanities in fields ranging from history through medicine and even journalism. While the chapters vary in quality as in the case in most symposia, the common theme is that the humanities are not a group of traditionally liberal studies, but "a timeless ideal that unifies, inspires, and invigorates the work of the scientists, artists, specialists, professional men, and workers, permeating all human activity and exalting the dignity of man's personality." The editors define the humanistic ideal as "a broad view of man's struggle to place himself in his environment," offering a noble tradition to guide him in his development. The volume ends with a pedestrian performance by Norman Foerster in which he sets forth the "Great Plan" for liberal education, based on a sweeping pattern of "The Great Curriculum," "The Great

Faculty," and "The Great Administration."

Cousins' volume is a challenge to social and political scientists to meet the issue set by natural scientists before it is too late. The other two volumes leave the reader with the wish that the use of a dispassionate and objective method of scientific inquiry, the courage to accept as valid the results of experiment, and the submission of logical proposition to empirical verification might be more widely used in dealing with our problems of group living in an age of atomic energy.

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A CRITICAL PERIOD IN AMERICAN BOTANY

American botany, 1873–1892: decades of transition. Andrew Denny Rodgers III. 340 pp. 1944. $3.75. Princeton University Press, Princeton, N. J.

THIS is the fourth of a series of works in which the author is presenting, with vastly more detail than has ever been attempted before, material for a history of the development of botany in the United States. The volumes have not followed one another in the chronological order of their subject matter. The first, *Noble fellow: William Starling Sullivant* (1940), stands somewhat apart both in its subject and in the method of its development. Sullivant, America's first real bryologist and still its greatest name in that branch of botany, was the author's ancestor, and the substance of the book is nearly as much historical and genealogical as botanical. There is no mention of botany in the first hundred pages, and Sullivant's interests were so nearly confined to mosses that the work is rather an account of the early development of bryology in this country than a history of its botany.

The second, *John Torrey: a story of North American botany* (1942), is in some ways the most successful of the author's four volumes. During the period it covers, essentially the years from about 1817 to 1873, "botany" in America meant taxonomy and floristics and little else. For much of that time Torrey was the recognized leader of North American botanists, in contact with practically all the active writers, collectors, and explorers, and intimately concerned in the elaboration of the material brought back by the numerous and important Government surveys in the western states, so that this account of his work gives a fairly comprehensive view of the development of botany in the United States during the period it covers.

The third volume, *John Merle Coulter: missionary of science* (1944), treats in detail of Coulter's botanical activities and teaching during more than half a century. Although his significant work began on his trips with Hayden's surveys in 1872 and 1873, just at the time Torrey's was closing, the field soon became so much broader and the number of botanists so much greater that the picture of botanical work with Coulter as a center here presented lacks the comparative completeness of the volume on Torrey.

The fourth of the series, *American botany, 1873–1892: decades of transition* (1944), naturally revolves about Asa Gray, with the paleobotanist Leo Lesquereux as the next most important figure, and Engelmann and Parry not far behind. Practically all the prominent and most of the minor botanists of the time are mentioned in its pages. Of its 14 chapters, 6 are concerned mostly with botanical expeditions and field work performed by many botanists; 1 with the establishment of botanical and agricultural laboratories and stations; 1 with paleobotany; 1 with a survey of Gray's work in fields other than taxonomy; 1 with the Gray-Greene controversy; and

4 are decidedly miscellaneous in character.

The book begins with an estimate of Gray's position in American botany after the death of Torrey, mention of many of the active workers of that date, and a discussion of Gray's activities or interests in such fields as evolution, heredity, insectivorous and climbing plants, and so on. The second, third, fourth, fifth, sixth, and twelfth chapters deal with the work of Government surveys and private collectors, particularly in the western states, but also in the southern United States, Canada, Mexico, and Central and South America. Lesquereux, Coulter, Rothrock, Parry, Greene, Palmer, Pringle, Brewer, Lemmon, the Parishes, Jones, Gattinger, Garber, Chapman, Curtiss, Mohr, Fendler, and Rusby are among the botanists mentioned, with copious extracts from letters. A long chapter, almost the only unified one in the book, is assigned to Lesquereux's investigations in fossil botany. The transition in the teaching of botany from the older purely taxonomic study to the wider curriculum inspired by European textbooks and graduate studies—a change in which Rothrock, Bessey, Beals, Farlow, and Goodale, only the last two of whom had European training, were especially concerned—is described in the tenth chapter, along with the establishment of experiment stations and the work of L. H. Bailey in scientific horticulture. A rather short but interesting chapter, with hitherto unpublished extracts from letters that passed between the three men, is devoted to Greene's controversy with Gray and Sereno Watson.

The index, which occupies 18 pages, seems very complete as to persons, localities, and institutions, although not so as to titles of publications cited in the text. A large amount of previously unpublished material from letters is incorporated in this as in the author's previous volumes. All of them would have been improved by competent editing.

Mr. Rodgers' four volumes are notable contributions of material for the history of North American botany that still remains to be written. In themselves they are too unsystematically arranged, too full of unessential detail, too lacking in trained botanical perspective, to qualify for this title. But until that history is written, they are likely to remain the outstanding source of information for it.

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FREEDOM OF RESEARCH

Science and the Planned State. Dr. John R. Baker. London. George Allen & Unwin Ltd. 1945. pp. 120. 7/6 net.

Professor Baker's book is perhaps even more important now than when it was written, for a couple of atomic bombs have been dropped on Japan, and the vernacular press, supplied with press releases by the politicians, is representing the development of the bomb as if it were the main line of progress and legitimate offspring in the field of radioactivity or nuclear physics, instead of a grotesque and disgusting aberration and abortion. This supreme manifestation of malevolence, the atomic bomb, has confirmed the ill-informed public in its appraisal of the scientist so long presented to them by the comic strip and dime dreadful. The scientist is essentially a fiend, who studies science, not for its own intrinsic interest, but solely for the purpose of acquiring control over men. According to the comics, the chief interest of the scientist is the destruction of the human race, and devising tortures for it. Professor Baker believes the man in the street is friendly to science and scientists. "The scientist is likely to be able to influence the mass of humanity more easily than the philosopher or the historian, because people tend to suspect

philosophy and ignore history, while trusting and respecting science" (p. 99). This optimistic appraisal of the popular attitude towards scientists was surely a very inaccurate judgment before Hiroshima, and is even more inaccurate today.

The politicians are playing up another angle: "Look," they say, "what a band of regimented scientists can do, when diverted from their frivolous pastimes of using radioactivity to date the strata of the earth, to modify chromosomes, to alleviate cancer, or make the faces of clocks shine by night. All we have to do is to provide a few billion dollars of taxpayers' money, pen the scientists up, and the loveliest bombs materialize. This shows that scientists ought to be under the control of politicians, because otherwise bombs might not be forthcoming, or, worse yet, the scientists might produce bombs not at the disposal of the political authorities." Arguments on these lines, to frighten the people into clamping vicious controls upon scientists, are now more insistent than when Professor Baker's book was written.

His book should be widely read, though the reviewer cannot concede that it is a very successful piece of writing. Although the subject matter is sufficiently clear that it should make possible a single forceful volume, it has not done so in Professor Baker's hands. The start is auspicious. The first three chapters go well. Here Baker is appraising accurately and understandingly the attitude of a true scientist toward the study of nature. The remaining two chapters must frankly be regarded as a detraction from the first three, and as leaving the reader with a feeling of uneasiness, not at the man-eaters to which Baker is pointing, but as to the ability of Baker to line up his gun with his target.

Chapter IV, "Science under Totalitarianism," is in large measure a denunciation of Russian control of its scientists. Much as most of us detest the whole Russian philosophy, and willingly though we might applaud a clear analysis of it, and of its effects, we feel that the author has not been too successful. Perhaps his personal knowledge in this field is not so good as in the field of his first three chapters; perhaps, however, it is that no man is emotionally equipped to sing a Schubert love-song and follow it immediately and convincingly with the German "Hymn of Hate." Or is it fair to expect a single author to write both the fourteenth chapter of St. John and a Catiline oration? And if he tries, is it fair to the reader to expect him to read them one after the other? And though Lenin be, as many of us think, as much a traitor as Catiline, and totalitarianism in Russia, as in Germany and Italy, a barbarous and vicious thing, yet Baker lacks the fire of Cicero and the analytical subtlety of Mark Antony, and the result is inadequate.

If the fourth chapter is unsatisfactory, the fifth and last is still more so. Here we have a potpourri of ideas, concerned indeed with the general subject matter of the ethics and social duties of the scientist, but having little to do with the Planned State as such. The reader feels the treatise petering out as he reads on: he wonders whether the chapter is put in to pack the covers of the book apart, and the good effect of the first three chapters, and the modest effect of the fourth, is largely dissipated.

Professor Baker could have written half a dozen valuable essays, and published them in the periodicals. Instead he has produced a rather rambling discourse, which is neither homogeneous nor frankly divided into separate items. The main subject matter, however, is so important, and the writings on the subject so few, that the reviewer must commend the author's efforts, and urge a reading of the book upon all who are interested in the future of science.

F. W. Preston

VALEDICTION

THEODORE HENRY FRISON

ONE day in the late summer of 1944 a charming and distinguished visitor came to the Brownstone Tower—Ted Frison, Chief of the Illinois State Natural History Survey Division. Although he had nothing pending with the SM and had many things to do elsewhere, he came to the Tower just to pay a friendly visit, for I had known Dr. Frison ever since the summer of 1922 when we worked at the Japanese Beetle Laboratory, then at Riverton, N. J. What a pleasure it was to see him! He always seemed youthful in appearance and spirits. Only his vanishing hair and his mirthful crow's-feet indicated that he had attained the age of responsibility. He was never thin but always slim and fit. In conversation he would lean forward and talk with enthusiasm about whatever projects were on his mind. And chuckles never failed to emerge as he told of his plans for the State Natural History Survey. It seemed incredible that one so young could hold such an important position. And yet he was primarily responsible for the growth of the Survey in physical facilities, personnel, and accomplishments which made it outstanding and unique.

At the time of Dr. Frison's last visit to the Tower he was beginning to suffer from the pain that incapacitated him during 1945 and resulted in his untimely death on December 9. One of his old friends, Dr. Alvah Peterson, wrote to me as follows: "Ted's death came as a distinct shock. He put up a wonderful fight but finally lost. I think of Ted as a close friend. He was a senior in the Champaign High School when I started my graduate work at Illinois. We played many games of tennis together and I learned to like him very much."

That a graduate student in entomology should have become acquainted with a high school senior is most unusual and calls for explanation. Dr. Frison was born in Champaign, Ill., on January 17, 1895. His family happened to live near the late J. W. Folsom, who was Professor of Entomology at the University of Illinois. Dr. Folsom noticed and encouraged the interest of his young neighbor in insects and introduced him to Stephen Alfred Forbes, who was then Head of the Department of Entomology at the University, State Entomologist, and Chief of the State Laboratory of Natural History. Impressed with his sincere enthusiasm, Forbes and Folsom allowed him to audit University courses in entomology before he graduated from high school. It was of course while taking this advanced work that he met Dr. Peterson.

Upon graduation from high school, Frison entered the University of Illinois, but his work was interrupted in his senior year when, in April 1918, he was commissioned a second lieutenant of infantry. At the end of 1918 he returned to the University, where he received his master's degree in 1920 and his doctorate in 1923. While at the University he played the violin in campus orchestras.

The State Natural History Survey was organized in 1917 with Forbes as Chief. In 1923 Dr. Frison joined it as Systematic Entomologist. Upon Forbes' death in 1930, Frison became acting head of the Survey and on July 1, 1931, he was named Chief. By this time he had made his reputation as a student of bumblebees. Later he specialized on stoneflies, despite his administrative work on the Survey, which took him outside of entomology and into all phases of the biolog-

THEODORE HENRY FRISON (1895-1945)

ical resources of the state and their conservation. To me, who early succumbed to paper work under burdens far lighter than those carried by Dr. Frison, it seems marvelous that he never ceased to make his own contributions to the natural history, identification, and classification of insects. He not only had to obtain appropriations for the work of the Survey and guide the work, but he had to plan the new Natural Resources Building in which the Survey is now housed. And with what enthusiasm he developed his plans and how proud he was of the completed structure! Under his administration his staff increased from sixteen in 1930 to thirty-eight in 1941.

Dr. Frison never forgot his fellow-entomologists and was always performing some service for them. By 1935 the *Journal of Economic Entomology* was in need of modernization. Dr. Frison undertook the editorship with the help of the Survey Editor, James S. Ayars. He changed the format of the *Journal* and working closely with a publication committee, of which I was a member, made the *Journal* a first-class technical periodical. How he found time to do it is still a mystery. He gave up the editorship in 1939. Had he lived, he would undoubtedly have become president of both national entomological societies, which he had already served as vice-president. He was, of course, a member of many societies and committees that had to do with the widespread activities of the Survey. The first meeting of the Midwest Wildlife Conference, held in Urbana in 1935, was largely the result of Dr. Frison's insistence on more and better wildlife research.

Dr. Frison was married to Ruby G. Dukes of St. Joseph, Ill., in 1919. Their son, Theodore Henry, Jr., who was born in 1924, has recently returned from Germany, where he served with the 99th Infantry Division. He was among the first ground troops to enter Germany and spent several months in a hospital as a result of injuries received during a winter campaign. The Frison's daughter, Patricia Ann, born in 1929, is a junior at Urbana High School. Dr. Frison spent many of his vacations driving with his family through the United States and Canada and was always on the alert to collect stoneflies, the nymphs of which are found in swift-running streams.

And now Dr. Frison has gone. He has done much for his fellowmen, but I think nothing he accomplished as a scientist and administrator will be remembered longer by those who knew him than the impact of his cheerful personality.

F. L. Campbell

COMMENTS AND CRITICISMS

The Limitation of Creative Years

I read with much interest the article by Dr. Lehman [SM, August 1945] and the extensive compilations upon which his conclusions are based.

It would seem that this work might have been still more valuable if an additional factor had been considered.

As a man advances and attains recognition in the intellectual fields, he is usually imposed upon by an increasing load of administrative, social, financial, or other noncreative duties. These will sharply reduce the time he is able to devote to his creative work.

In the case of the industrial scientist, it is well known that the man who has made his mark at the age of a few and thirty will usually be "promoted" to functions in which he no longer has the opportunity to devote himself principally and exclusively to personal creative work. The same holds true in large sections of academic work.

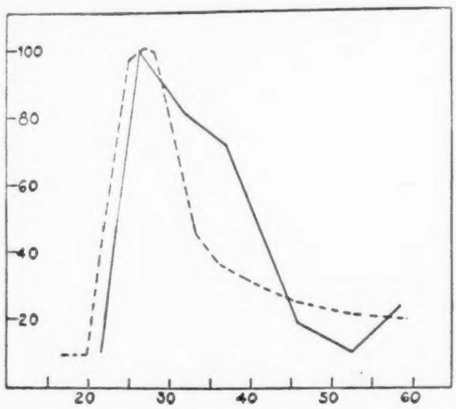
Therefore, the curves showing absolute performance in relation to the age factor are in reality composite curves between performance curves and a curve showing the decreasing amount of time which the scientist is permitted or able to devote to creative functions. In the accompanying graph is shown the percentage of creative working time, obtained by interviews with only a small number of successful chemists within the writer's acquaintance. While obviously the possible limit of error is large, there is no question that a large decrease in the time free for creative work generally occurs at or somewhat before the age indicated as the top creative age in Dr. Lehman's study. The curve for output in chemistry has been copied from Dr. Lehman's Fig. 9.

This would appear to indicate that the decrease in absolute results is due not to a sharp decline in creative capacity, but to a decline in the actual daily working hours freely available for undisturbed pursuit of creative tasks.

Accordingly, it is misleading to conclude, for example, that a man has reached his peak capacity at 28, because at that age he turns out his most valuable result.

If his result at a certain age is rated 100 and is attained with an average working time of 10 hours per day this obviously would indicate a lesser producing capacity than if a result rated 50 were turned out in only 4 hours per day, the remaining 6 hours being devoted to equally strenuous but noncreative duties such as administration, teaching, representation, etc. Yet this is exactly the position encountered by most successful men in the scientific professions, as they attain wider recognition with progress in time.

If the true ability of output or creative ability is to be computed for any age, it is therefore submitted that the absolute value of this output is not sufficient but that the output divided by the number of hours free for such use is much the truer indication and that neglect of this time factor will very significantly lead astray in any inferences drawn.



WHY GENIUS WITHERS

Solid line, AGE VERSUS OUTPUT IN CHEMISTRY (LEHMAN'S FIG. 9). *Broken line*, AGE VERSUS PERCENT OF TIME AVAILABLE FOR CREATIVE WORK.

In conclusion, the suggestion might be offered that the sharp decline at the age of about 30 is a result of the fundamental characteristic of human organisms of indiscriminately loading all types of work on those who possess ability to carry it without regard for the desirability of reserving peak capacities exclusively for truly creative work. If this tendency could be checked, certainly results of the utmost importance to *Homo sapiens* would ensue.—JOHAN BJORKSTEN.

Dust-devils?

I learn from the September SM that controversy about the Carolina bays is not yet stilled, and that a new hypothesis is promised [see Major Grant's hypothesis, December SM]. In that case may I submit some fresh information that seems to bear upon the problem?

As land-forms the Carolina bays are not unique. Very similar characters are apparent in some of the South African salt pans. I have visited some of these pans, but I am no geomorphologist, so their shape failed to impress me at the time and the observations I now offer are mostly second-hand.

The Grootpan, or great salt pan, at Zwartkops, near Port Elizabeth, is an almost perfect oval, about 1500 yards long and 1000 yards wide. It lies on a sandy coastal plain, and it is surrounded by a sandy rampart 30 to 50 feet high which is covered with scrub. The almost flat floor of the pan carries a shallow lake of brine, surrounded by a wide crust of salt. No adequate topographic map of the coastal plain has been made, but it is likely that aerial photographs are now available. There are many other pans in the neighborhood, but their shape has not been recorded. I think I am right in saying that the Carolina bays were almost unnoticed until aerial photographs drew attention to them. There are thousands of large and small salt pans in South Africa, many on the coastal plain, and many more in the dry interior. I know that many of them are quite irregular in shape, but some of the pans in the Kalahari are "circular or oval." The following, tantalizingly brief descriptions are taken from F. C. Cornell's book, *The Glamour of Prospecting* (New York, Stokes & Co., 1920):

p. 251—The pan "was about a mile in width, almost a perfect circle in shape."

p. 260—"Though the majority of the dunes trend between WNW and ESE, this uniformity is broken in the vicinity of the numerous pans, around which the dunes are often formed in concentric rings."

p. 261—"Many of the circular or oval pans are surrounded and protected by dunes of well over 100 feet in height, as with a wall." The dunes are exceptionally high on the south side.

p. 262—"The big pan Kobo-Kobo . . . is one of the most perfect pans in the desert, as true a circle as though drawn by a compass, surrounded by extremely high dunes, and with a perfectly level, spongy alkaline floor."

p. 266–267—"The pan is about 2 miles wide by 5 miles long. . . . Its perfectly level floor of light blue shale [is] surrounded by hills of reddish sand." Tall dust-devils play always over the floor.

The photographs on pp. 242 and 254 of Cornell's book illustrate these brief descriptions.

It seems to me that the fundamental factors in any explanation of the Carolina bays or the South African salt pans are: (1) a region of wind-blown sand such as a recently formed coastal plain; (2) either salt springs or else shallow depressions where salt water lies close to the surface, and consequently there is (or was formerly) no vegetation to bind the sand together; (3) the occurrence of "dust-devils," or whirlwinds, which waltz around on the hot, bare surface in the dry season, drawing sand and dust up into the air, to fall again outside the cyclonic area.

By this means a low rampart of sand may accumulate around the pan, and because of its higher elevation it will in time have its salt content leached out by rain water. Plants will then take root in the rampart and fix it in place (the Salt Pan condition); and if the rainfall is sufficient the floor of the depression may eventually be washed free from salt, and vegetation will spread all over it (the Carolina Bays condition).

I realize that this does not explain everything, but I think you will agree that there is a remarkable parallelism between the South African salt pans and the Carolina bays.—S. JAMES SHAND.

The Social Significance of Jewish-Christian Intermarriage

Intermarriage is not only a means to bring about the blood mixture of the two racial-confessional groups and thus to further a biological assimilation, i.e., a gradual fusion of the one group into the other; the social importance for both parts is much farther reaching. It consists first of all in the fact that in a great part of mixed marriages the respective relatives of the marriage partners come into close contact. The anti-Semitic attitude of the governmental circles in Hitler's Germany would never have

been criticized at all if through intermarriage many parts of the Christian population had not also been affected. Thus not only the Jews, those by faith and those who had been baptized, but many Christian families received an immediate idea of the barbarism of this new racial and pseudoscientific doctrine. People who had lived with one another in great harmony were torn apart; family ties that had long existed had to be forcefully severed. This makes evident the great importance of intermarriage on the social side, a psychological and sociological importance which cannot be esteemed high enough for the future solution of the problem.

In this way, contact was established between parts of the population which previously had been, if not hostile, at least strange to one another. Often true friendship arose in these circles which withstood even Hitler's reign of terror. On the whole, the mixed marriage has been the best means to bring the two groups together socially, to draw the Jewish minority out of the intellectual ghetto, in which they voluntarily still frequently live; and furthermore to convince the Christian majority that the Jews, whose Holy Writ they have completely taken over into their new edition of the Bible, are as contemporary human beings not very different in beliefs and sentiments from themselves. They have only held on to their older faith and thus bred certain "racial characteristics." The real existing differences can be easily explained biologically through inbreeding and selection resulting from the fanatic persecutions over many centuries and sociologically from the fate of the remaining Jews in a strange, often hostile environment.

Thus it is the most important task and almost a *social mission* of the mixed marriage to bring the two population groups together on an equal basis and fuse them also in a spiritual union. The same function is fulfilled by true friendship among Jews and Christians, for which there are many historical and personal examples; the same function is fulfilled by the common intellectual and social participation in all branches of modern culture, in art and science, in business and trade. No social ties, however, can cause such intensive approach as intermarriage with its bonds of blood through the offspring and the close social relations which derive from it.

To be sure, just in recent years there have been some severe objections to assimilation from the Jewish side. The events in Germany and especially the racial hatred against the Jews have, according to these arguments, furnished the best and most impressive demonstration that assimilation is impossible, because it is undesired. Even the new German idea of isolation and racial superiority will not be able, after the total defeat of the Nazi rule, to resist the forces of biological assimilation and sociological rapprochement. However, one would have to discuss this important point in a special chapter on the fundaments of Jewish nationalism and German anti-Semitism, which certainly is not a new invention. (It was as violent already in the mob assaults in Alexandria at the time of the Greek-Jewish philosopher Philo.) Just now that much may be said: Whoever joins in these arguments represents, too, the German racial idea of *Blut und Boden* (blood and soil), or the pseudoreligion of the race on the Jewish side. There are enough analogies in the Jewish religious legislation of pre-Christian time, which is frequently cited by Aryan race mythologists for this purpose. Yet it is totally overlooked, for lack of historical knowledge or for other reasons, that a large majority of the Jewish people has been assimilated in the course of the centuries and has thus proved its desire and capability of being assimilated.

It has been computed by trusthworthy research workers that since the beginning of the Christian Era from two-thirds to three-fourths of the original Jewish stock has disappeared; in all probability for the larger part through merging within the surrounding peoples (Beloch, Ruppin, Fishberg, Wellisch, etc.). Instead of 15 or 16 millions of Jews there would be at least 50 or 60 millions in the present world if they had increased at the same rate as the other nations. Only a relatively small part has been biologically destroyed; i.e., prevented from further biological reproduction.

A simple consideration will make this tendency obvious without going into details of the calculation. The census taking place under the Emperor Augustus counted or estimated 54 million people in the Roman Empire, of them 4½ millions were Jews in the different parts of the Roman world (Julius Beloch). If we follow the well-known Jewish demographer Arthur Ruppin and add further 20 million white Caucasians outside the then boundaries

of the Roman Empire, including ½ million Jews, we arrive at 5 million Jews among 74 million people. That is, a proportion of almost 7 percent. At the present time, counting not the entire world population of more than 2,100 millions but only the population of European descent which may vary between 900 and 1,000 millions, the round 15 millions of confessional Jews in the different parts of this civilization before the onslaught of Hitlerism represent a share of 1.5 to 1.7 percent only. From this simple consideration it follows that the largest part of the original Jewish people has been biologically assimilated.

All such calculations are necessarily based on estimates; but the tendency of a much slower increase of the Jews since the Christian Era is, beyond doubt, correct, although naturally the absolute number of the Jews, too, is larger today than at the time of Christ. This obvious tendency of a biological fusion would prove larger yet if pre-Christian history, especially the absorption of the Ten Tribes of Israel by the Assyrian mixture of peoples, were included in the calculation. That the Jewish racial mixture, consequently, is no foreign one among other Caucasian peoples should have become plain. Extant differences can be rationally explained through inbreeding and selection like similar differences between other national and ethnic groups.

However, some *irrational* or less visible obstacles will still have to be removed in a conflict of religious doctrines and traditions before a complete solution is feasible. Intermarriage or biological fusion is only one step, though indeed a radical one, demanding the courage for genuine assimilation, a courage no less than that of persisting in the dogmatic ritual and marital laws of ancient legislation. These laws were renewed and intensified by the priests Ezra and Nehemiah (around 500 B.C.), after the return of the remainder of the Jewish people from the Babylonian Exile, through austere measures, forbidding and dissolving all mixed marriages. At that time such measures were justified or essential for the preservation of Jewish monotheism. In this respect we may quote the historian Josef Kastein who says in his new history of the Jewish people (*History and Destiny of the Jews,* p. 76):

"Ezra's measure was undoubtedly reactionary. It raised to the dignity of law an enactment which at that time was not included in the Thorah and could be justified only in the circumstances then in existence. The preservation of the race and of their religion alike indicated its necessity, while it also proved that those responsible for it recognized that the Jews might be possessed of particular qualities. . . . The Jews were engaged in an attempt to realize an extremely lofty ideology in their life as a community, an attempt which was on the verge of ending in failure. If failure were possible even in the case of a community which was the outcome of selection, how much greater must not the danger have been where foreign elements, alien both in race and culture, had been admitted. Thus Ezra was fully justified in deliberately and methodically applying the principle of isolation as an educative means."

Almost 2,500 years have passed since. The Jews are no longer the only representatives of the monotheistic idea of God. Monotheism, even though not in the exclusive form of the Jewish national religion, is today shared by around 750 million Christians and 250 million Mohammedans. The ethical ideas of the Jews have to a far-reaching extent been taken over by the daughter-religions. Therefore, at the present time the religious seclusion and the biological inbreeding are no longer justified even as principles preserving the monotheistic idea of God. Rather, social and spiritual fusion has to be added to the biological one. Only this presents an actual *reconciliation* and *reunion* of the Old and the New Faith, in order to liberate the Jewish people from its spiritual ghetto, or from its "chimeric existence among other peoples" as it was formulated a century ago by the Hegelian and religious philosopher Bruno Bauer. The same meaning is in the inspired words by the distinguished Jewish scholar Morris Jastrow, Jr., in his treatise about Zionism and the future of Palestine, published after the end of the first World War: "I would like to envisage a Palestine that may become a beacon-light for the world, that may again become a spiritual focus, furnishing further inspiration for mankind as it proceeds in its march through the ages to a still higher, albeit unknown and unknowable, goal."

Such a religious reconciliation with its biological and social consequences would certainly be a more permanent and more perfect solution than a new national state in Palestine or elsewhere such as the Zionists are longing for. "A Jewish State," Jastrow concluded his ex-

position, "would simply mean a glorified ghetto, narrow in its outlook, undemocratic in its organization, and that may well turn out to be reactionary in its tendencies." A movement for a homestead of the brutally persecuted Jews in the present world upheaval is quite different from a new Jewish theocracy in Palestine. Such a movement is an urgent necessity; yet it must not aim at a new Jewish nationalism and a new religious seclusion. Nationalism has always and everywhere narrowed the mind. A permanent solution can only be founded on the basis of an international Covenant of Nations.

Such a World Organization, however, should be inspired by a superseding religious idea rather than by the political idea of the old League of Nations. This would mean the true religion of brotherhood in the Biblical sense, and its symbolic seat could well be the Holy Land: the ancient home of the Jews, the cradle of Christianity, and the present possession of the Islamic world. That is the realistic meaning of reconciliation of the Faiths and the Nations on this shrunken earth. Towards such reconciliation a greater religious idea must take the lead, in our age of mass destruction, if there is to be a future of mankind.—GEORGE WOLFF.

"Beach Cusps" or Beach Grooves: their Genesis

Dr. O. F. Evans presented an interesting article in the October SM, "Scientific Beachcombing," describing the formation of "beach cusps." A greatly simplified version of his definition of these cusps is that they are temporary points of sand extending into the water and occurring in series.

I cannot see that it is the cusps that are formed. Cusps appear to me to be what remains after a special wave action erodes a series of grooves, leaving the intervening points of the beach intact.

Dr. Evans writes: "It was an old problem, this question of how beach cusps are formed, and had been the subject of discussion, study, and experiment by geologists and other nature students for more than a century. Many articles had been written and many theories advanced, by both laymen and scientists, yet the answer seemed as far away as ever." In a footnote he refers to his article in the Journal of Geology (1938, pp. 615–627). In this he states that W. D. Johnson, in *Shore Processes and Shoreline Development,* (John Wiley & Son, N. Y. 1919, pp. 457–486) has summarized the literature on the subject and found no acceptable solution. Dr. Evans classified cusps in five categories, but the first four cover exceptional cases, not referring to the phenomenon discussed here. It is evident that investigators have satisfied themselves by studying the beaches and not the waves.

Dr. Evans describes what he considers to be the discovery of the process which forms the cusps. He noted a small sand ridge that had been built up during the previous hours; next he noted that a "*new breeze*" was moving in from the lake and the waves were just reaching the shore. The swash and backwash of these new waves broke the sand ridge. He states that succeeding waves made the spacing of the breaks more even, but he gives no reason *why* they should become more even. He goes on to say that the formation is due to the [unexplained] ability of the waves to break the ridge into segments. He comes to the crux of the whole problem when he says: "This [breaking into segments] they can do because of the *slight inequalities in the height of the wave crest.*" The italics are mine. He does not explain the origin of the slight inequality or why these inequalities should be evenly spaced or strike at the same point on the beach. The only piece of the jigsaw puzzle that he lacked was apparently the most important one, namely: *how* the waves came to have high points and *why* succeeding high points hit the shore at the same spots.

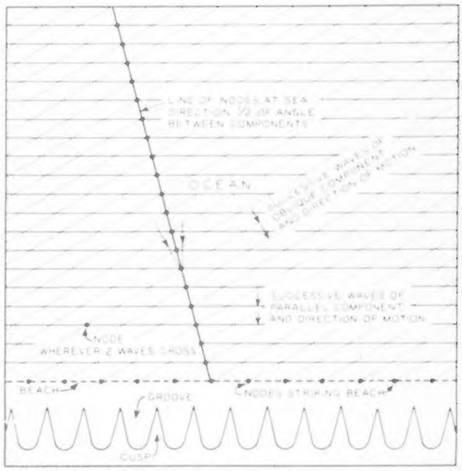
I have spent literally hundreds of hours on the bow of Army transports, passenger steamers, and sailing vessels studying marine life and wave formations. One interesting phenomenon which has always interested me is the coexistence of several systems of waves. One may see a heavy ground swell traveling in one direction, a smaller system of waves traveling merrily in another direction, and occasionally a third system of ripples caused by the local breeze traveling in a third direction. When two systems are traveling at an angle I have noted that there is an increased volume of water where the crests cross and hence greater striking power. We may call this point a "node."

Let us follow these crisscross waves to the beach. This can be done easily by a diagram

(see the accompanying drawing). Let us draw a series of heavy parallel lines on a piece of paper and another series of lines on a piece of tracing paper which we will place over the first piece. By slight rotation we can cause our wave series to cross at any desired angle. Next we place the ruler on the edge of the paper to represent the beach line. For simplicity it should be parallel to the heavier system of waves. At each point where the oblique lines cross the beach line a node has hit the beach. Thus it can be seen that the width or spacing of the beach grooves is not only influenced by the size of the waves but also by the amplitude of divergence of the oblique component—the greater the obliquity, the greater the width of the groove spacing. If the main component reaches the beach parallel thereto we have the nodes hitting fairly close together—or at a distance equal to the internodal distance measured along the crest of the component moving parallel or nearly parallel to the shore.

It must be noted that the three factors—size, direction, and speed of the waves of the two components—may cause a great number of combinations of which only a few are suitable to the formation of beach grooves. A beach remains about static from year to year, so the forces of erosion and deposition balance in the long run. A node is only a momentary fact—the instant that the oblique crest rides past the parallel component the node no longer exists, but another comes into being when the oblique motion again crosses the parallel motion. The nodes form in lines which bisect the angle made by the components. If these lines are not straight, grooves cannot form. All parts of each component strike the beach, but it is only when and where a node strikes that the additional force is exerted that starts the erosion of a groove. For the sake of simplicity we must assume that our waves are traveling at just the right speed to intersect at the beach as shown in our diagram. It is obvious that one set of waves may have farther to travel than the other and hence must move faster. In nature it is seldom that the right timing exists for the formation of grooves. The oblique component may be invisible from the beach and it need not be large to be effective.

Dr. Evans states that he has measured cusp series some of which had a spacing of over 20 feet. The photograph accompanying his article



shows the spacing to be about 60 feet by comparison with automobiles shown on the highway skirting the beach. These grooves show that many cubic yards of sand were shifted below sea level to effect their completion. Sixty feet is just about what one would expect in the case of a mild Pacific Coast surf —the photo was taken near Santa Barbara.

Dr. Evans gives figures to show that there was considerable variation in spacing of the cusps in the cases which he studied—up to 147 percent. If it is a fact that there is variation on a straight beach my theory is inadequate and probably any other theory covering repeated heavier waves striking repeatedly in the same spots would also be inadequate. Neither Dr. Evan's photograph nor his diagrams show any such variations as he mentions in his text.—CHAPMAN GRANT.

Belated Acknowledgment

It has been brought to my attention that I did not point out the contribution of Anglo-Canadian institutions to French Canada. ["Science in French Canada," September and October 1944 issues of THE SCIENTIFIC MONTHLY.] Maybe I should have insisted on the training many French Canadians received in the past, and still do, in engineering, medicine, and agriculture at McGill University and Macdonald College. The latter, under a special research grant from the Government of the Province of Quebec, has been especially active in plant breeding and seed-growing, and the population of this Province as a whole has benefited greatly thereby.—PIERRE DANSEREAU.

THE BROWNSTONE TOWER

In the issue for September 1944, page 243, we published a letter from Peter Hidnert, which I entitled "The Ragged Edge." Dr. Hidnert wanted to know why the cover pages of the SM were larger than the inside pages. It would be better, he thought, to trim all around so that handling would not quickly reduce the magazine to a dog-eared condition. We agreed with him, for one cannot readily name a periodical, except *Science*, which has remained unshaven up to 1945. But, because wider margins were needed for trimming and binding, we could not trim all around while paper restrictions were in force. Now we have reduced the area of type on each page to that used in 1943 and at last present a trimmed magazine of 100 pages.

The biography of the inventor John Ericsson was offered to us by *The Reader's Digest*. We accepted it not only because of its intrinsic interest but because it demonstrates the biographical technique of a well-known novelist. This biography may be published later by *The Reader's Digest* in condensed form.

Harwood's article on phenothiazine is the second personalized account of research to be published in the SM since we appealed to our contributors to provide human stories of detection. Harwood conducted phenothiazine to its triumph as an anthelmintic, but he did not know its earlier story in the Bureau of Entomology and Plant Quarantine. That story is told in detail in *Record for Party Smith*, 1937, being the verbatim report of a hearing in which the Government presented evidence to try to convince the patent examiners that the Bureau's chemist, L. E. Smith, should be granted a patent on the insecticidal use of phenothiazine instead of Du Pont's chemist, E. W. Bousquet, whose claims were in interference. After appeal, the case was finally decided in favor of the Government, but by that time phenothiazine did not look so promising as an insecticide as it had when Dr. J. W. Bulger first detected its high toxicity to mosquito larvae. But in the end, as Dr. Harwood relates, the insecticidal investigations of phenothiazine paid off by way of experiments on the control of horn flies. Thus veterinarians became aware of phenothiazine and thus its unique usefulness as a vermicide was soon disclosed. Perhaps the earlier history of phenothiazine should be written for the SM, and perhaps I should do it, for I was there.

The symposium on Early Man in Oregon was presented at a meeting of the Oregon Academy of Science. These three papers were originally written in conventional scientific form with full documentation. At our request all three authors tried to recast their papers for the benefit of our lay readers.

Our concluding essay by Lt. (jg) Platt came unsolicited. We think the Lieutenant has some sensible and pertinent suggestions to make about our national defense. Although he does not speak for the Navy, he will be identified with the Navy. It seemed courteous therefore to ask the Army to name an unofficial proponent in this debate. Consequently we requested Colonel Harold W. Kent of the General Staff Corps to find a young officer able and willing from personal conviction to write an essay for the SM in favor of universal military training as proposed by President Truman. Thus we obtained the article by Captain Curzon. As the captain won his commission the hard way—induction, basic training, officer candidate school—he knows what he is advocating when he recommends universal military training.

F. L. Campbell